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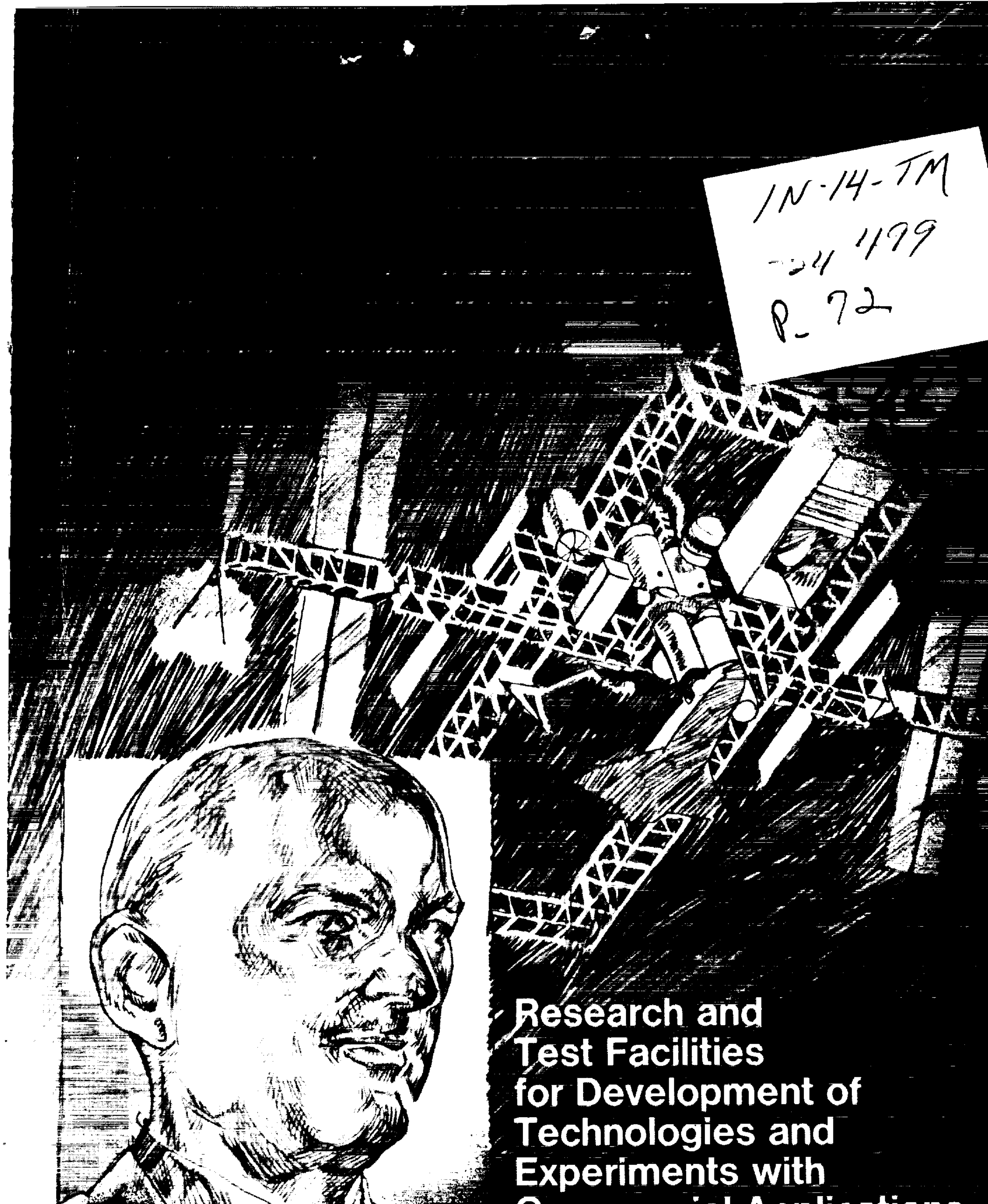

Research and Test Facilities for Development of Technologies and Experiments with Commercial Applications

NASA

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

FOREWORD

This document was prepared by the Goddard Space Flight Center Commercialization Committee under the direction of Donald S. Friedman, Chief, Office of Commercial Programs.

The purpose of this document is to summarize the Goddard Space Flight Center facilities and capabilities available for use by private entities involved in developing experiments with commercial potential.

Further information may be obtained from:

Office of Commercial Programs
Goddard Space Flight Center
Code 702
Greenbelt, MD 20771
Telephone (301) 286-6242

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INTRODUCTION

One of NASA's Agency-wide goals is the commercial development of space. To further this goal NASA is implementing a policy whereby U.S. firms are encouraged to utilize NASA facilities to develop and test concepts having commercial potential.

Goddard, in keeping with this policy, will make the enclosed facilities and capabilities available to private entities at a reduced cost and on a noninterference basis with internal NASA programs.

Due to the complexity of GSFC's research, analysis and testing facilities, it is not possible to list all of our capabilities explicitly in a document of this size. However, it is hoped that the enclosed information will encourage you to contact the Office of Commercial Programs and the facility contact should you desire additional information.

SPACECRAFT HARDWARE TEST

INTRODUCTION

The Vibration Facility performs shock and vibration tests on spacecraft and subsystems, reduces test data and calibrates transducers. The facility is composed of the following systems:

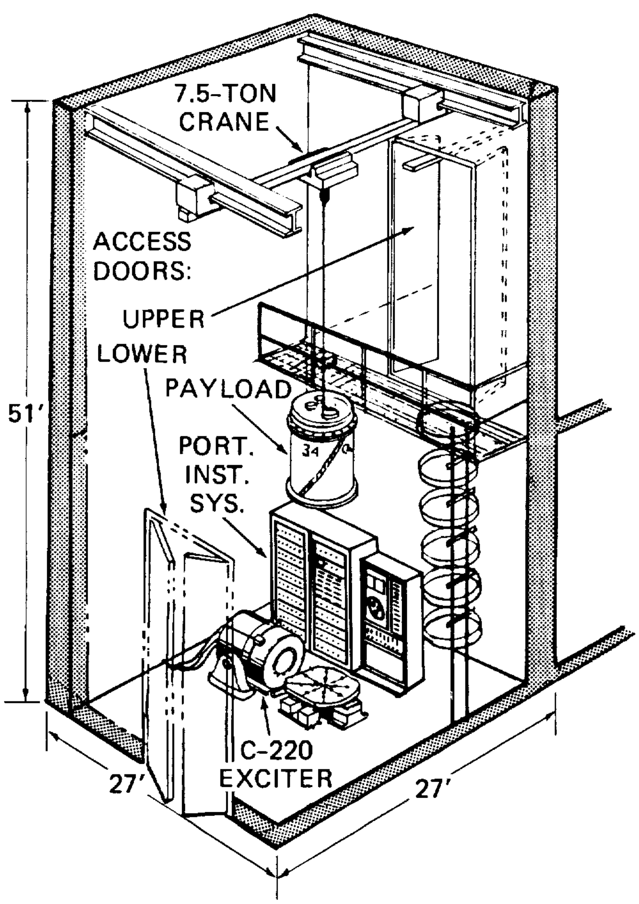
- Vibration Control and Data Acquisition Systems
- Vibration Exciters

Facilities are available for the calibration of control and response accelerometers.

VIBRATION CONTROL & DATA ACQUISITION

DESCRIPTION

The GENRAD 2503 digital control and analysis system controls shock and vibration inputs to the MB C-220 and LING B-335 exciters. Accelerometers, strain gauges and related transducer signals are conditioned and recorded on the Data Acquisition System.



MB C-220 Exciter Facility

MODE OF OPERATION

Three control strategies are available: Sinusoidal Vibration, Random Vibration and Transient Waveform Control. Develop required control specifications by keying in test parameters at the terminal.

The Data Acquisition System provides real-time data monitoring on meters, plotters and oscillographs while simultaneously recording all signals on magnetic tape. Record jobs of up to 14 channels at the Vibration Control Instrumentation Rack. Record all other jobs with the Permanent Instrumentation System or portable System.

PARAMETERS

Vibration Control System

Sine:

Frequency range	5Hz to 2KHz
Dynamic range	72dB

Random:

Frequency range	5Hz to 2KHz
Dynamic range	60dB
Breakpoints	up to 32

Transient Waveform:

Pulse types	Half-sine, sawtooth, double rectangular, rectangular, triangular
Pulse amplitude	0.1 to 10,000 g
Pulse duration	0.5 to 1000 msec

Data Acquisition Systems

Accelerometer signals	0 to 10,000 g
Strain gauge signals	0 to 10,000 microstrain

INTEGRAL INSTRUMENTATION

The GENRAD 2503 contains its own keyboard terminal with CRT monitor and digital plotter.

The Data Acquisition Systems have SANGAMO, HONEYWELL or TEAC tape recorders, TRICOM or VIDAR FM multiplex systems, CEC or Honeywell oscillographic recorders, charge amplifiers and strain gauge amplifiers.

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VIBRATION TEST FACILITY


GENRAD Vibration Control System

DATA ACQUISITION

Vibration Control

The GENRAD 2503 system can record from 1 to 4 control accelerometers and control on the minimum, maximum or average of the signals. For protection, loss of signal causes automatic shutdown.

Data Acquisition Systems

Permanent system ..... Up to 86 accel. channels

Portable system .... Up to 98 accel. & strain (max. of 30) channels

Vibration control rack .... up to 14 accel. channels (including facility channels)

MB C-220 EXCITERS
LING B-335 EXCITERS

DESCRIPTION

Two MB C-220 exciters (1 existing and 1 proposed) are used to test large payloads. Two separate Ling 8096 power amplifiers drive either exciter via a Ling automatic switching system. Each exciter has its own cooling unit and lateral slip table supported by hydrostatic bearings.

Two LING B-335 exciters test small- to medium-sized payloads. A single LING 8048 power amplifier drives either exciter. Each exciter has its own separate cooling unit.

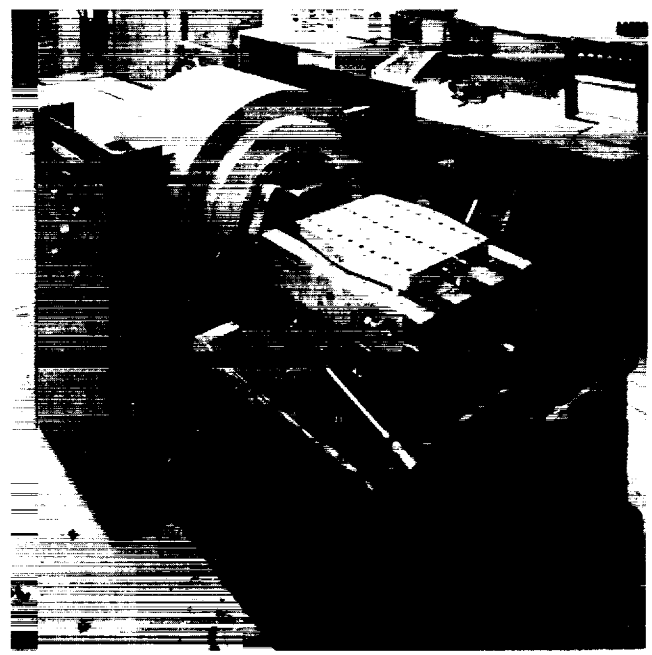
One exciter is set up in the vertical mode and the other is connected to a TEAM 1830 Lateral Table.

MODE OF OPERATION

The present MB C-220 exciter is located on a seismic block in a class 10,000 downflow clean room. Load the test item on the exciter with a 7.5 ton overhead bridge crane. Rotate the exciter from vertical to the horizontal position to perform 3-axis testing. (The proposed MB C-220 exciter will have similar performance criteria and operations except it will not be in a clean room.)

Both Ling B-335 exciters are located on seismic blocks in a common test cell of general lab cleanliness. Load the test item with a 2 ton overhead monorail crane that services either exciter. Perform thrust axis testing on the vertical exciter and lateral axes testing on the horizontal exciter.

Use a small machine shop for simple layout and customized fixture fabrication.


Ling B-335 Exciter

PARAMETERS

	MB C-220	Ling B-335
Force rating		
Sine vector	35,000 lb	17,500 lb
Random RMS	28,000 lb	12,000 lb
Frequency range	5 Hz to 2 KHz	5 Hz to 2 KHz
Displacement limit	1.0" D.A.	1.0" D.A.

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Velocity limit	70"/sec	70"/sec
Vertical centering capability	5000 lb	2000 lb

PHYSICAL CHARACTERISTICS

	MB C-220	Ling B-335
Test cell	29'L x 27'W x 51'H	37'L x 15'W x 19.5'H
Lower access door	8.3'W x 16'H	8'W x 16.7'H
Upper access door	16.2'W x 29.4'H	N/A

INTEGRAL INSTRUMENTATION

Protective interlock circuits integral to the power amplifier monitor 12 vital parameters and automatically shut down the system if a malfunction occurs.

Control accelerometer signal #2 is connected to the U-D 123 vibration monitor limiter (which has selectable acceleration and displacement limits for overtest protection).

CONTACT – George R. Springham, Jr., Code 754.1 (Structural Dynamics & Electromagnetic Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6480.

BATTERY TEST FACILITY

DESCRIPTION

The Battery Test Facility conducts tests of aerospace batteries and cells under simulated space environmental temperatures. The facility includes:

- Computer Control System "L"
  - HP 1000 Computer
  - Power System Exerciser (PSE)
  - Digital Voltmeter/Data Scanners
- Environmental Test Systems
  - Temperature Chambers
  - Cold Plate
- Data Processing System "J"
  - HP 1000 Computer
  - Line Printer
  - Plotter

Computer Control System "L" automatically controls 5 individual tests simultaneously. Preprogram test parameters into the HP 1000 computer to establish identification, control the test and establish a data base for logistics and data acquisition.

Test condition (TC) files contain the number of sub-steps within a test, step dwell times, upper/lower safety limits and PSE controls. The system automatically selects the TC file to be used for each test sequence and the start and stop times for each test.

The PSE:

- provides selectable voltages, currents and power loads used to test batteries or cells per TC files issued by the control computer, and
- monitors critical safety limits with automatic cutout when a limit is exceeded.

A digital voltmeter measures test voltage, current, resistance and temperature. Data scanners scan data from commands received from the master computer and TC files. Input data is routed to scanners via selectable receptacles.

Environmental Test Systems: Test batteries or cells are housed in an environmental test chamber or mounted on a cold plate for temperature control during tests. The cold plate provides refrigeration only to remove heat from the test battery's base plate.

Data Processing System "J" is used to write and debug software and compile data. Data is transferred from System "L" output tapes to disk libraries.

System "J" also tests new equipment and PSE components during development for future use in System "L."

MODE OF OPERATION

Initiate a test in 3 stages.

- Mount the component in/on the environmental test chamber or cold plate.
- Connect test cables between the test component and the PSE test station. Connect data cables between the test component and data scanner input receptacles.
- Preprogram test parameters into the HP 1000 computer master files, TC files, and sequence files. The computer controls the test, and also, records output data on magnetic tape and hard disk.

Preset safety limit checks are made each minute on all test channels. Out-of-limit conditions automatically pause the applicable test and print alarm message(s).

PARAMETERS

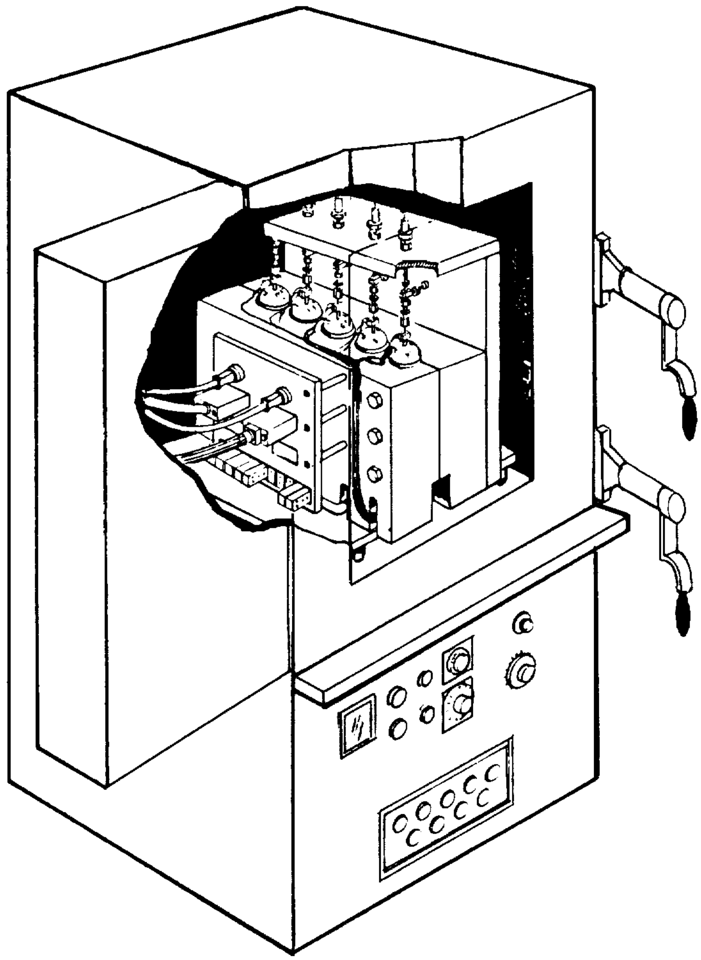
No. test stations	5
Temperature range	-40° to 100°C
Analog data input channels	120
Temperature channels	40
Test types	Aerospace secondary batteries or cells requiring voltage, current, resistance & temperature measurements
Test voltage	0 - 40 volts
Test current	0 - 100 amps

PHYSICAL CHARACTERISTICS

Systems "L" and "J" are in 6 separate 6′ relay racks. Systems are permanently housed in Building 22. Portable systems are used for test and evaluation and launch support.

INTEGRAL INSTRUMENTATION

System components interface with the HPIB (IEEE) buss, allowing interface to peripheral equipment,



Battery Under Test

e.g., printers, plotters, digital-to-analog converters, and terminals.

Channel capability expandable to 240 channels.

CONTACT – Smith Tiller, Code 711.2 (Energy Conversion & Power Processing Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6489.

LARGE AREA PULSED SOLAR SIMULATOR FACILITY

DESCRIPTION

The Large Area Pulsed Solar Simulator (LAPSS) irradiates solar cell(s) and solar panels with simulated solar radiation. The system has four major components:

- Pulse Forming Network (PFN),
- lamp housing,
- data acquisition system, and
- electronic loading network.

The LAPSS provides a uniform, spectrally-balanced pulse of light to the test object. The LAPSS electronically loads the solar panel during illumination, and records and conditions the data for rapid retrieval.

The voltage/current characteristics of the solar cell(s) or solar panel may be displayed on a CRT, printed out, plotted, and/or stored on magnetic tape. A standard cell is provided to measure the actual illumination level.

The LAPSS system, and operating staff, are protected by a fail-safe interlock network. All operations are controlled from a main control console and the computer.

MODE OF OPERATION

Load the operating parameters into the data acquisition system and the power system. Start the run at the computer.

The Pulse Forming Network is charged, and upon reaching a preset voltage value, a trigger circuit is energized and the illuminator lamps are flashed. This flash illuminates the solar cell(s) or solar panel with a light pulse for 2 milliseconds, during which the intensity is nearly constant.

During this flat section of the light pulse, a ramp is output by the electronic load. This load is seen by the test article and causes the operating point to sweep from short circuit to open circuit.

As this is taking place, the voltage and current outputs from the test article are measured simultaneously with the output from the standard reference cell. These readings are taken approximately every 10 microseconds.

After the flash is completed, the data are stored in the computer's internal memory ready for display with the CRT, printer, and/or plotter.

PARAMETERS

Illumination	1AMφ (135.3 mW/cm^2)
Target diameter	2.5 meters
Light pulse duration	2–3 millisec
Uniformity @ 13 meters	±1.0%
Spectral match (sun equivalent)	±3%
Voltage range	0–100 volts in 7 ranges
Current range	0–20 amps in 8 ranges
Standard Cell temperature	28°C

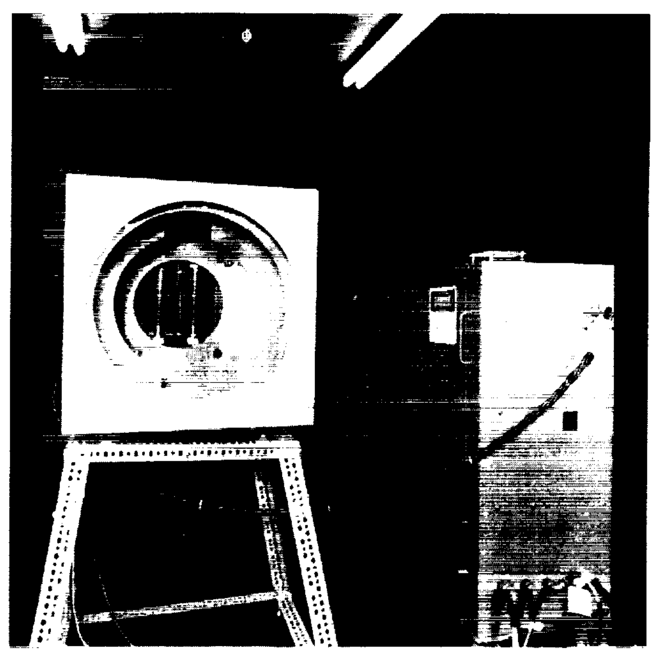
Single point voltage select for solar cells

PHYSICAL CHARACTERISTICS

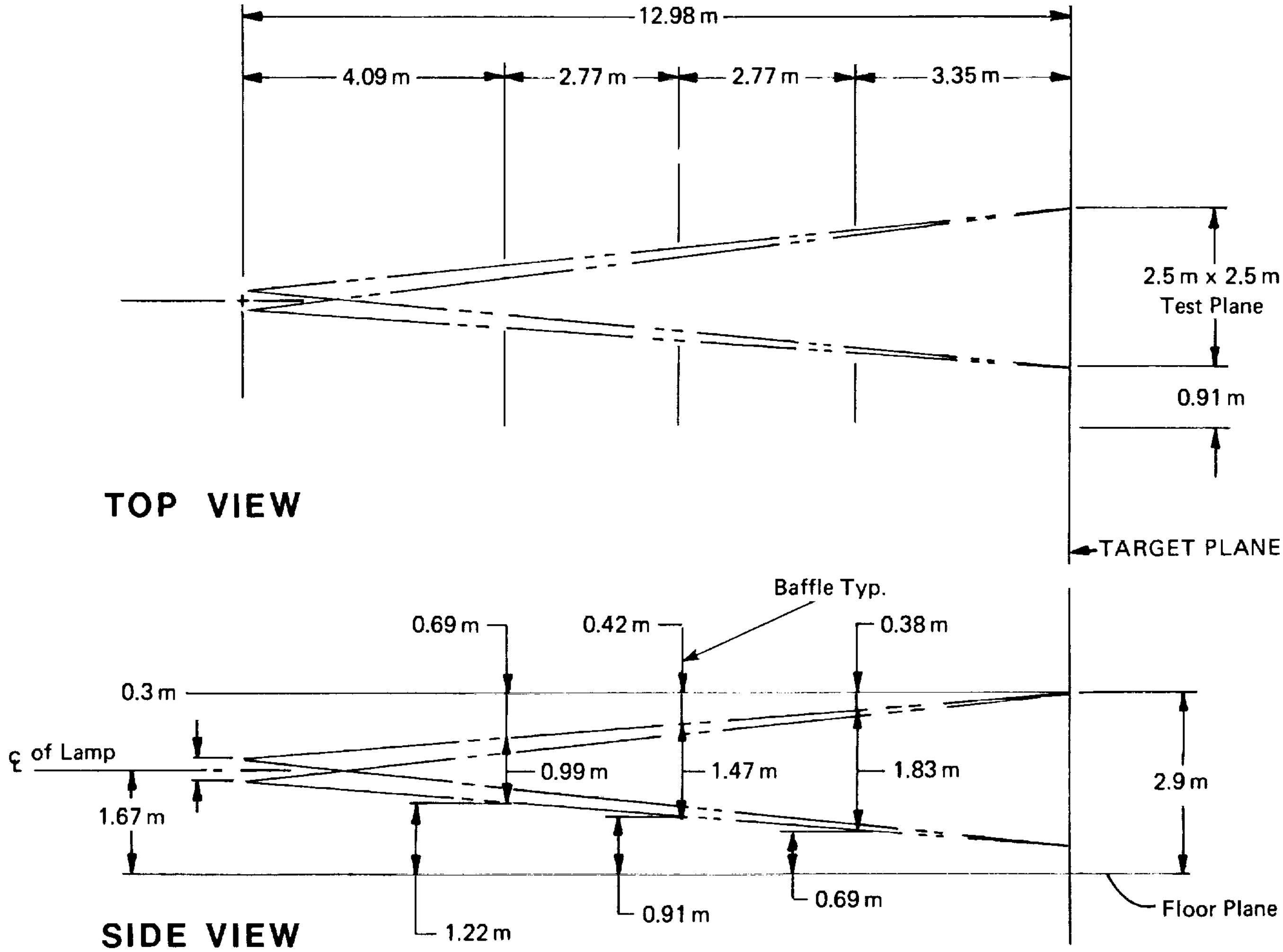
The LAPSS is housed in a 50'L x 10'W x 8'H flash chamber that is painted flat black inside and has three baffles for collimation.

INTEGRAL INSTRUMENTATION

Up to 50 individual solar cells can be tested per setup using a sequencing unit. The user must provide cabling.



Lamp Housing & Pulse Forming Network



LAPSS Test Facility

The solar cell(s) or solar panel are mounted on a metal frame. The 4-wire output provides resistance-free output for single solar cells. Balloon-flown (quality controlled) standard cells are used as reference cells.

DATA ACQUISITION CAPABILITIES

An HP 85 computer derives voltage, current, temperature and power directly or mathematically.

CONTACT – Joel B. Jermakian, Code 711.2 (Energy Conversion & Power Processing), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-5752.

HIGH VOLTAGE TESTING FACILITY

DESCRIPTION

The High Voltage (HV) Testing Facility performs all of the standard tests on electrical insulations for space use plus partial discharge tests which require specialized equipment. This specialized apparatus includes partial discharge (corona) detection equipment with associated high voltage power supplies for AC, DC and AC/DC superposed applied voltages.

HV can be brought out of the test cabinet through corona-free feedthroughs to test objects while in vacuum. Equipment for HV Life-tests, HV capacitance and resistance measurements is available.

MODE OF OPERATION

DC to 60kV, ±2%, manual or motorized ramp, variable speed.

AC to 40kV RMS, ±5%, manual or motorized ramp, variable speed, 60 Hz.

AC/DC superposed, to 38kV DC and 12kV AC, 60 Hz.

Hardwire test object between HV bushing and ground.

PARAMETERS

Pressure .... ATM to 10^{-6} torr

Pulse Distribution Histogram with,

1. No. of pulses .... for practical purposes, unlimited
2. Charge content of corona pulses or partial discharge .... resolution to 0.2 pC depending on calibration range

Capacitance of test specimen ...... up to 30,000 picofarads

PHYSICAL CHARACTERISTICS

Test Volume

cabinet .... 24"L x 14"W x 20"H

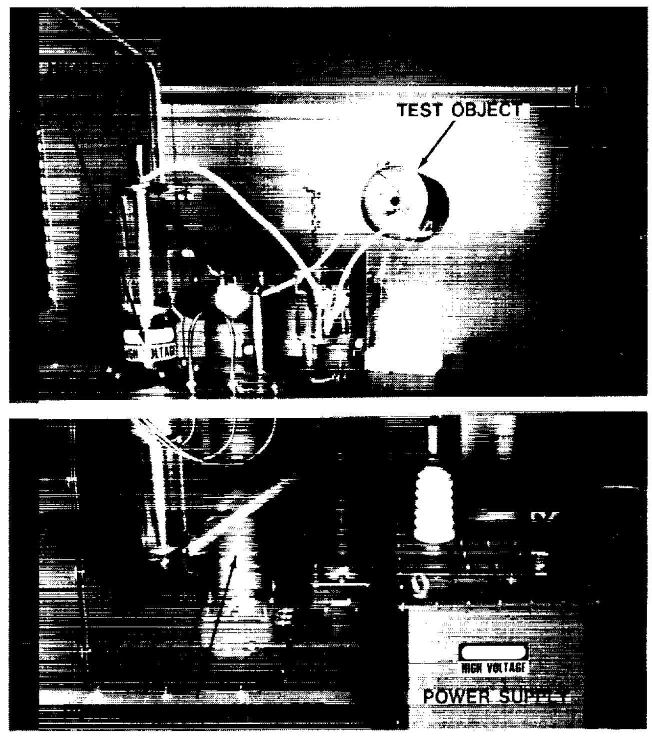
vacuum chamber .... 9"L x 9"W x 16"H

INTEGRAL INSTRUMENTATION

ND 65 Multichannel Analyzer in Pulse Height Analysis mode (gives number of pulses, charge content, total summed corona charge transfer in given time interval).

DATA ACQUISITION CAPABILITIES

AXIOM Printer data output from ND 65 Multichannel Analyzer (ND 65 could be connected to a computer if desired; it has full ASCI keyboard interface capabilities).

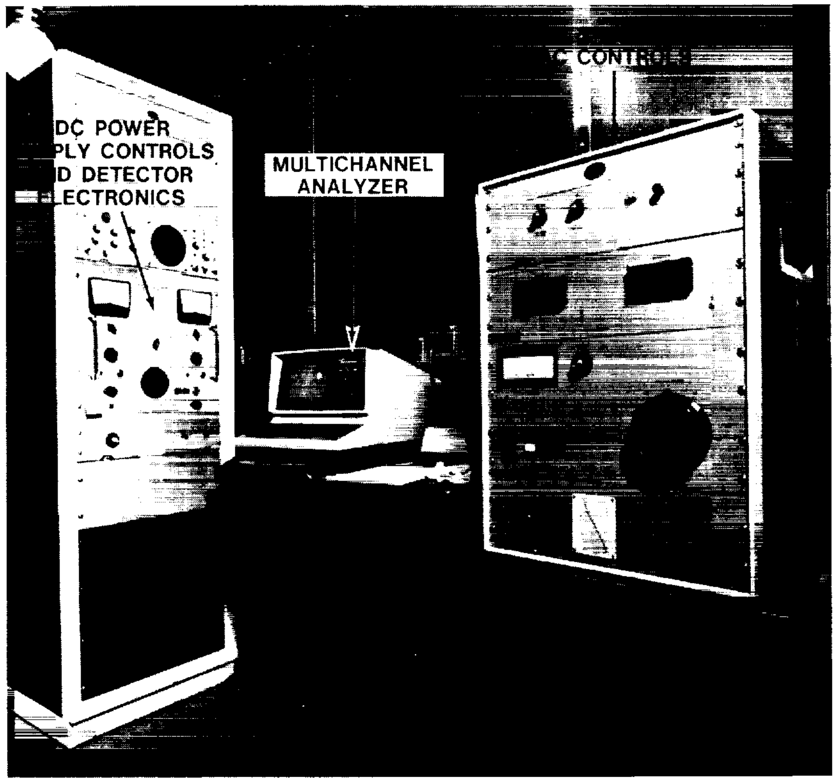


Partial Discharge Test in Ambient Air

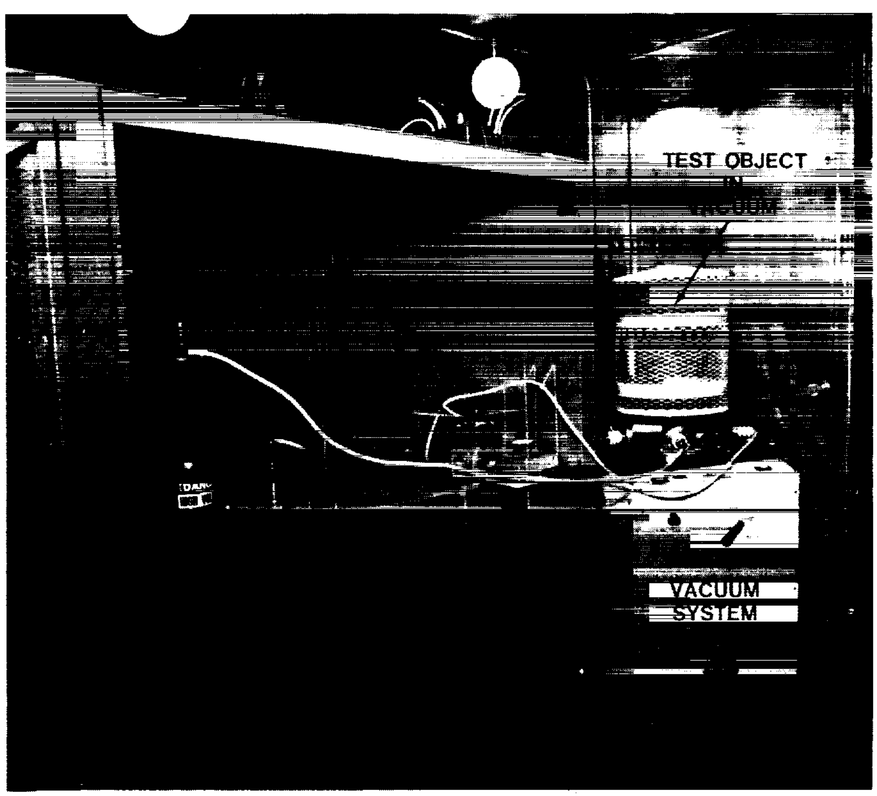
FACILITY INTEGRATION OPTIONS

Test cabinets, controls, and vacuum system housed in an electrically-shielded room with 2 filtered isolated power lines.

CONTACT – Renate S. Bever, Code 711.3 (Payload Interface & Instrument Power Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, (301) 286-2383, or 286-4434.



Control Cabinets



Partial Discharge Test in Vacuum

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MAGNETIC FIELD COMPONENT TEST FACILITY

DESCRIPTION

The Magnetic Field Component Test Facility (MFCTF) contains a 20-foot diameter triaxial circular coil system with associated support and handling equipment, plus a removable vacuum chamber. It is used primarily for calibrating and aligning magnetometers. Other test activities include magnetic field measurements of subsystems and components.

MODE OF OPERATION

- Prior to installing the test magnetometer, establish a zero field at the center of the coils.
- Use a reference standard proton magnetometer to calibrate the coil system.
- Position the test magnetometer (or test article) on the platform at the center of the coils and aligned to the coil axes.
- Generate static and dynamic fields to establish the linearity, frequency response, zero offset and alignment characteristics of the test magnetometer.

PARAMETERS

Static Field Capability

Magnitude (each axis)	±60,000 NT
Resolution	±0.1 NT
Homogeneity	0.001%

Dynamic Field Capability

Magnitude (each axis)	±60,000 NT
Resolution & stability	±120 NT
Frequency	0 to 100 rad/sec

PHYSICAL CHARACTERISTICS

Coil access opening	5′ x 5′
Building access opening	10′ x 10′

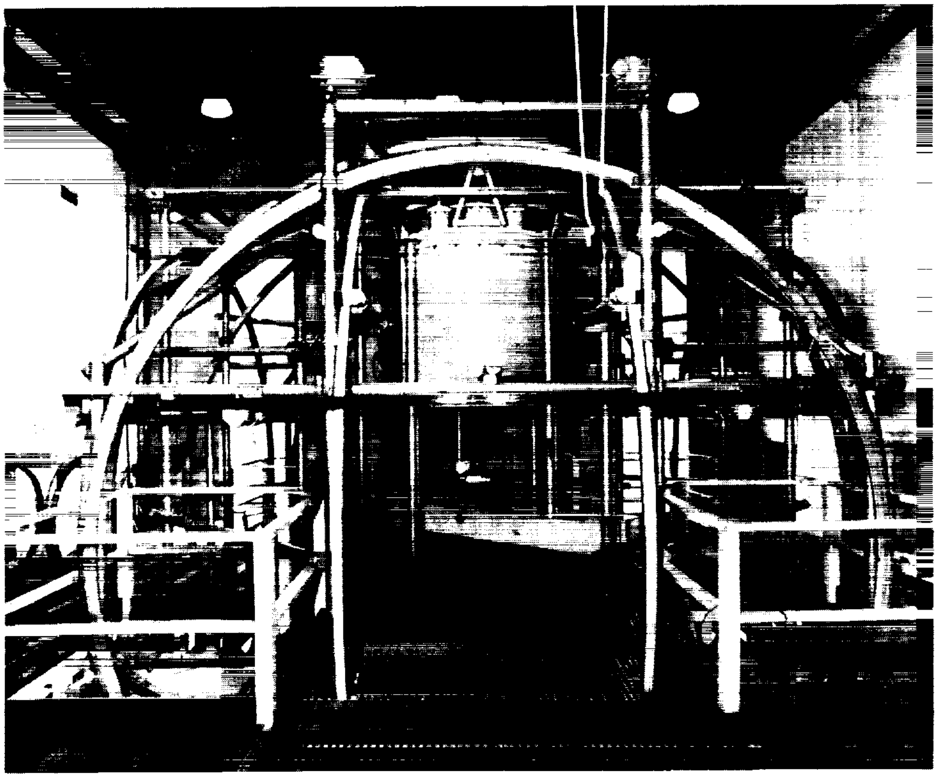
INTEGRAL INSTRUMENTATION

The MFCTF is equipped with instrumentation for calibrating and aligning magnetometers. This instrumentation includes fluxgate and proton magnetometers for field zeroing and calibrating.

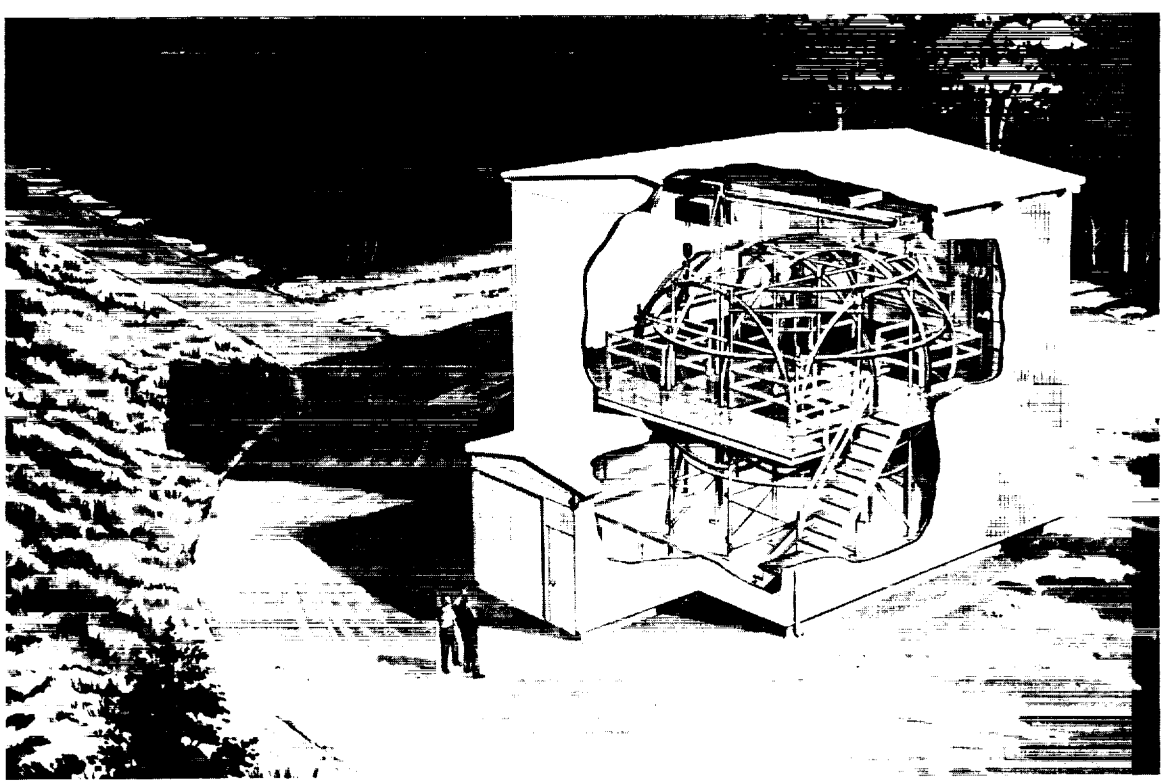
FACILITY INTEGRATION OPTIONS

The facility contains a non-magnetic thermal vacuum chamber which demounts and is normally positioned outside the center of the coils. Theodolite platform and external reference marks provide a precision alignment capability.

CONTACT – George R. Springham, Jr., Code 754.1 (Structural Dynamics & Electromagnetic Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6480.



Interior View of Coils and Vacuum Chamber



Magnetic Field Component Test Facility

SPACECRAFT MAGNETIC TEST FACILITY

DESCRIPTION

The Spacecraft Magnetic Test Facility (SMTF) contains a 40-foot diameter triaxial circular coil system with associated support and handling equipment. It is used for magnetic testing of spacecraft, sounding rockets, attitude control systems, magnetometers and subsystems.

MODE OF TESTING

Magnetic Testing

- Prior to installing the test item, establish a zero field at the center of the coil.
- Use a reference standard proton magnetometer to calibrate the coil.
- For each measurement sequence, move the facility dolly with the test item to the center of the coil.
- Obtain magnetic field data in accordance with the test procedure.
- Store data in the computer for immediate display and processing of test parameters.

Sounding Rocket/Magnetometer Calibration

- Initial testing steps are same as above, except when the test item is moved to the center of the coil, align the test item with the coil axes.
- Generate static and dynamic fields to establish the linearity, frequency response, zero offset, and alignment characteristics of the test item.
- Store data in the computer for immediate display and processing of test parameters.

DATA ACQUISITION CAPABILITIES

A data acquisition/control unit mates with the HP 86 computer and provides 20 data input channel capability. It measures voltage, resistance, temperature and frequency. Test data is stored on disk in digital format.

PARAMETERS

Static Field Capability

Magnitude (each axis)	±60,000 NT
Resolution	±0.1 NT
Stability	±0.5 NT
Homogeneity	0.001%

Dynamic Field Capability

Magnitude (each axis)	±60,000 NT
Resolution & Stability	±120 NT
Frequency	0 to 100 rad/sec

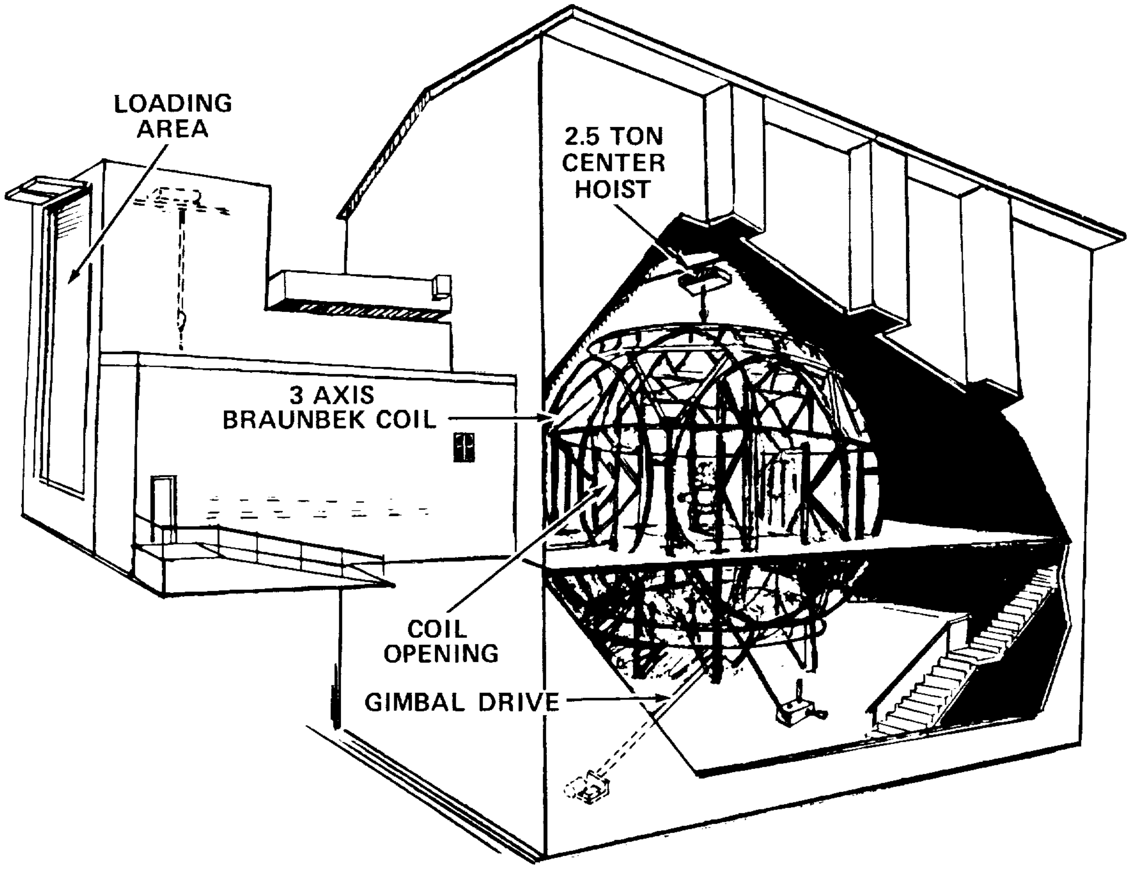
PHYSICAL CHARACTERISTICS

Facility access opening	14'W x 15'H
Coil access opening	10' x 10'
Hoists lifting capabilities	5T, 3T, 2.5T
Clean room (center of coil)	class 10,000

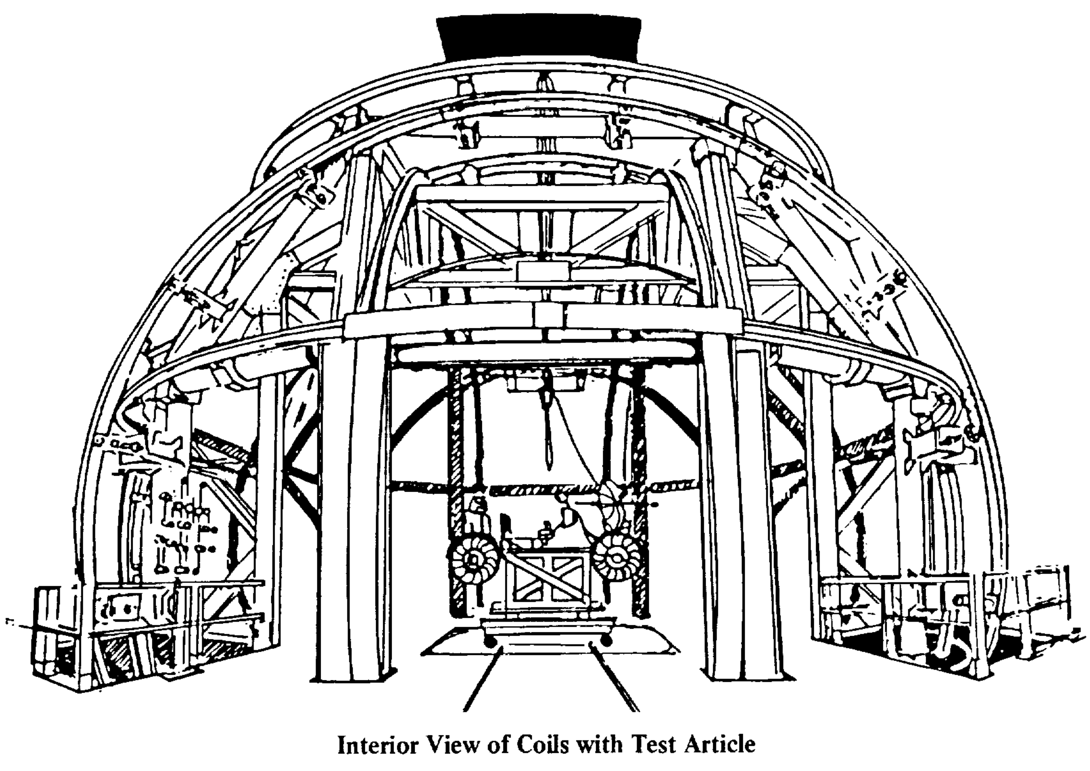
INTEGRAL INSTRUMENTATION

The SMTF is equipped with single and triaxial magnetometers, proton magnetometers, torquemeter, and data collection instrumentation. It also contains 4', 5', and 10' HELMHOLTZ perm/deperm coils and associated 60 Hz AC and DC power supplies.

CONTACT – George R. Springham, Jr., Code 754.1 (Structural Dynamics & Electromagnetic Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6480.



Spacecraft Magnetic Test Facility



Interior View of Coils with Test Article

HIGH CAPACITY CENTRIFUGE FACILITY

DESCRIPTION

The High Capacity Centrifuge (HCC) simulates launch and landing loads on spacecraft hardware. Payloads are installed in a cylindrical test chamber (radius 60 ft) or on a test platform (radius 51 ft). It is powered by two 1250 HP DC motors operated in conjunction with a motor generator set. Controlled deceleration is possible by using the drive motors in a regenerative mode.

MODE OF OPERATION

1. Mount payload in test chamber by attaching test article to removable end cap.
2. Loading vehicle picks up and positions end cap so it can be attached to test chamber.
3. Use 3-ton crane to position test article on test platform.
4. Use tilt fixtures to orient test article in proper attitude.

PARAMETERS

Chamber

Nominal test radius	60′
Maximum test weight	5000 lb
Maximum test acceleration	30 g
Maximum speed	38.3 RPM

Platform

Nominal test radius	51′
Maximum test weight	5000 lb
Maximum test acceleration	25.5 g
Maximum speed	38.3 RPM

PHYSICAL CHARACTERISTICS

Test chamber size	12′ dia x 22′L
Platform dimensions	12′ x 12′
Platform height (above floor)	8′
Crane capacity	3 T
Rotunda dimensions	157′ dia x 27′H

Slip rings:

Instrumentation and Control	24 (5A) 986(1A)
RF	6
Power	30-100A @ 600V
Movie systems	3 (16mm)
CCTV system	2

INTEGRAL INSTRUMENTATION

Instrumentation includes: *Speed*-HP 5512A Electronic Counter, *Arm Unbalance*-Brush Recorder, and *Drive Motor Voltage and Current*-Omega Recorder.

DATA ACQUISITION

Data signals are conditioned onboard and transmitted by slip rings to the control room for recording and display. Movies and CCTV are provided.

CONTACT – George R. Springham, Jr., Code 754.1 (Structural Dynamics & Electromagnetic Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6480.

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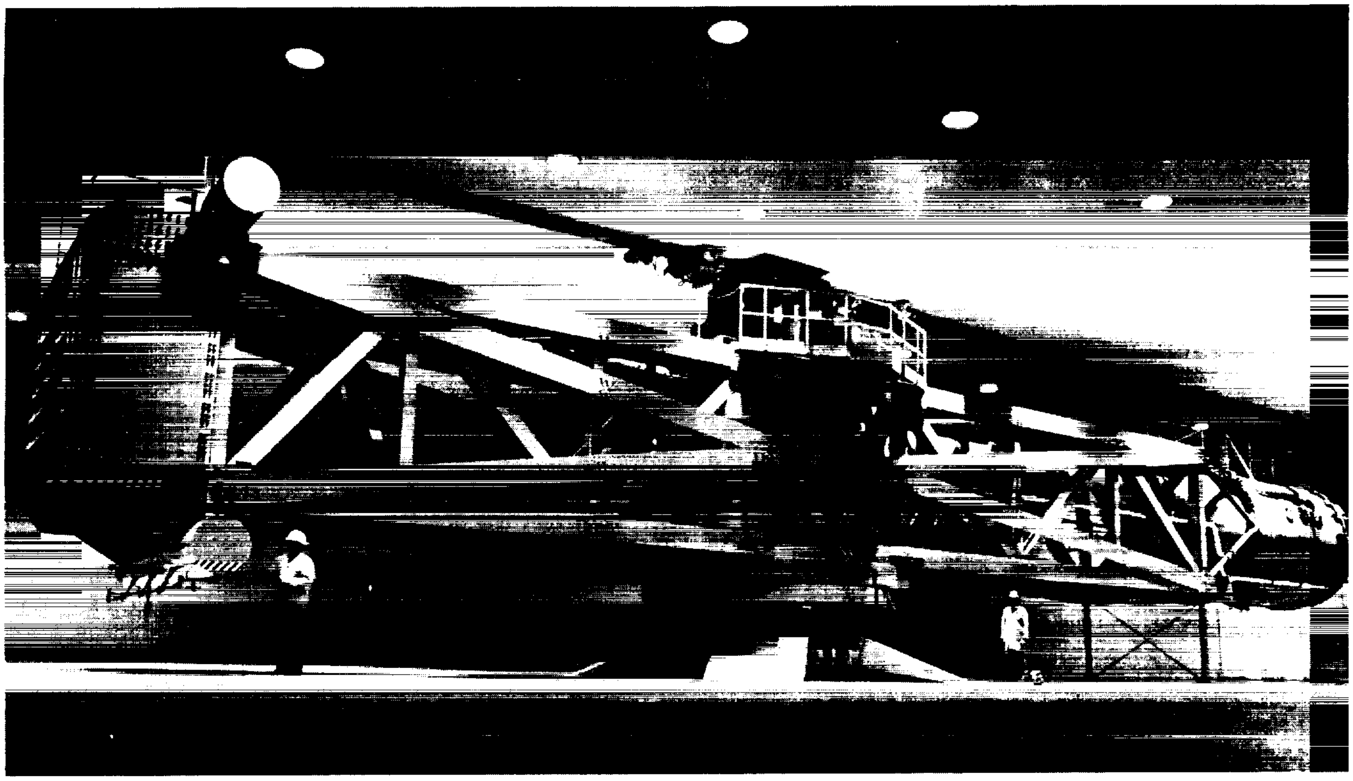
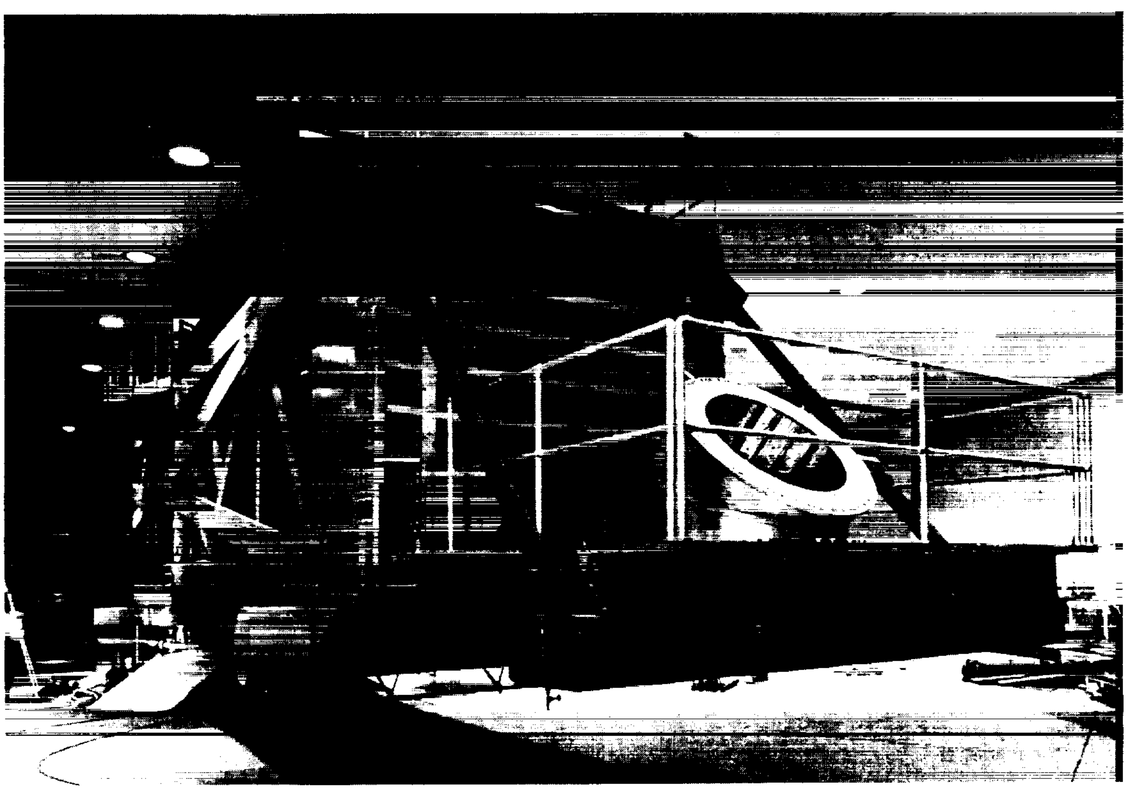


High Capacity Centrifuge



Test Platform on Weight Bucket End

ACOUSTIC TEST FACILITY

DESCRIPTION

The Acoustic Test Facility tests various sized scientific satellites, subsystems and components. It consists of the reverberation chamber, acoustic horns, noise generators, control console and data handling system.

MODE OF OPERATION

The chamber is shaped to the required spectrum prior to installation of the payload. Suspend small and medium sized payloads on crane hook at the center of the chamber. Place large payloads on carts or fixtures. Place 4-6 control microphones (minimum 1′ away) around the payload.

Generate acoustic energy by flowing of GN2 through the generators attached to the horns. Use fresh-air forced ventilation system to stabilize chamber pressure during operation of the facility and purge the chamber of GN2 for safe entry after test.

PARAMETERS

Generators (4)	4-10 KW Electropneumatic
Horns	25 Hz Exponential, 50 Hz Hypex, 75 Hz Exponential
Maximum OASPL	150dB
Frequency Range	25 Hz to 10 KHz

PHYSICAL CHARACTERISTICS

Interior	33′L x 27′W x 42′H
Payload access	15′8″W x 30′H
Personnel door	3′W x 6′6″H
Crane capacity	7.5 T

INTEGRAL INSTRUMENTATION

The forward loop instrumentation system (a random noise generator, band pass filters, 1/3 octave equalizer and power amplifiers) drives the acoustic generators and controls the spectrum of the chamber. The aft loop system (control microphones, charge amplifiers and 1/3 octave real time analyzer) is used for real time analysis of data which can be displayed on the video display terminal.

DATA ACQUISITION CAPABILITIES

Microphone, accelerometer and strain gauge signals are recorded on a portable instrumentation system or transmitted to the "A" mezzanine for recording. A 1/3 octave band analyzer is used for post test analysis. A CCTV is also available for observing and recording the payload condition during test.

FACILITY INTEGRATION OPTIONS

The facility can be operated as a clean room (Class 100,000) once the payload access doors are closed and the facility is cleaned. An anteroom is used for changing into clean garments before entering the facility through the personnel door.

REFERENCES

1100 M³ Acoustic Facility Operating Procedures, NSI-11-0004, Northrop Services, Inc.

Acoustic Facility Handbook, NSI-12-07-024, Northrop Services, Inc.

CONTACT – George R. Springham, Jr., Code 754.1 (Structural Dynamics & Electromagnetic Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6480.

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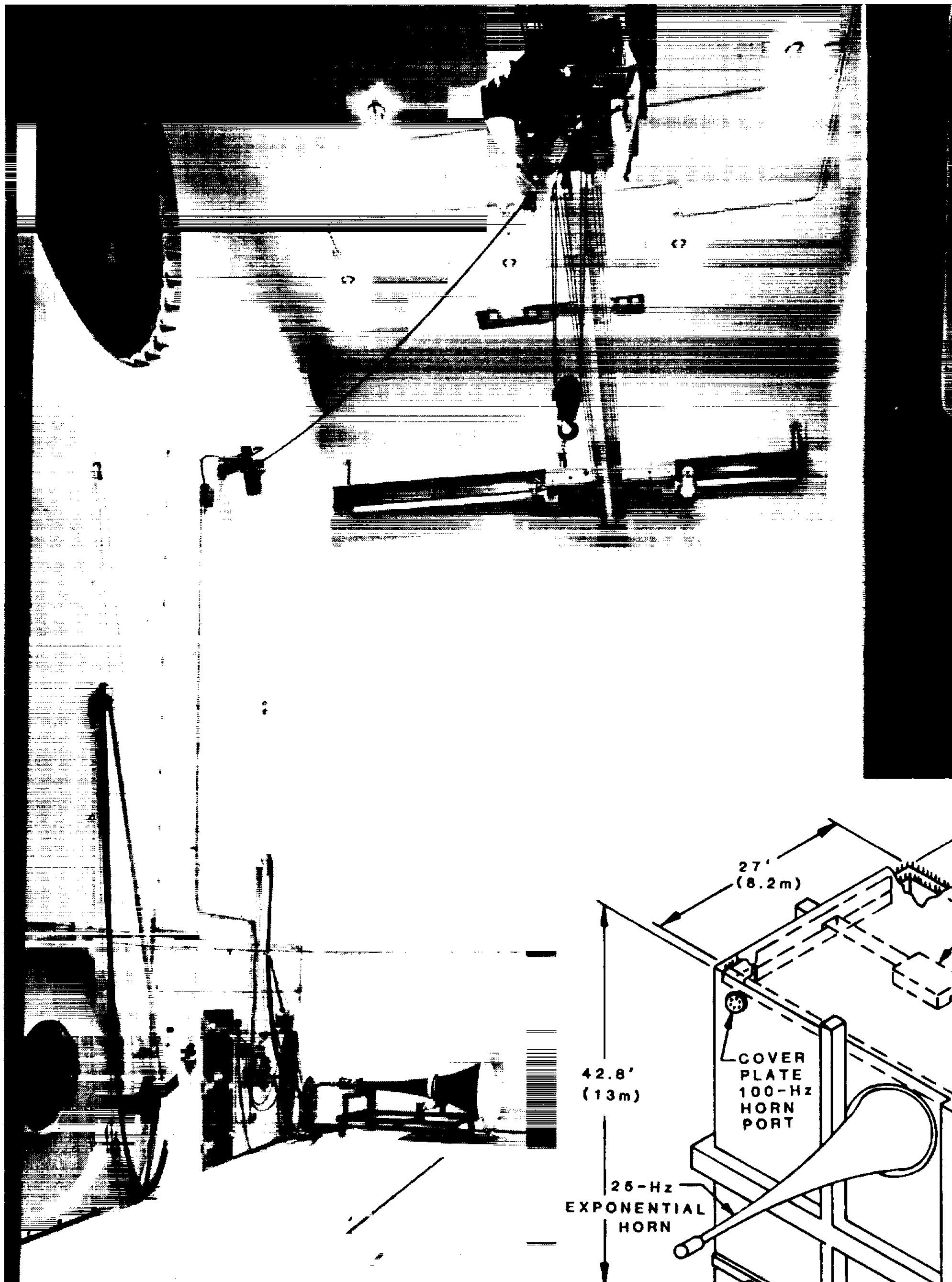
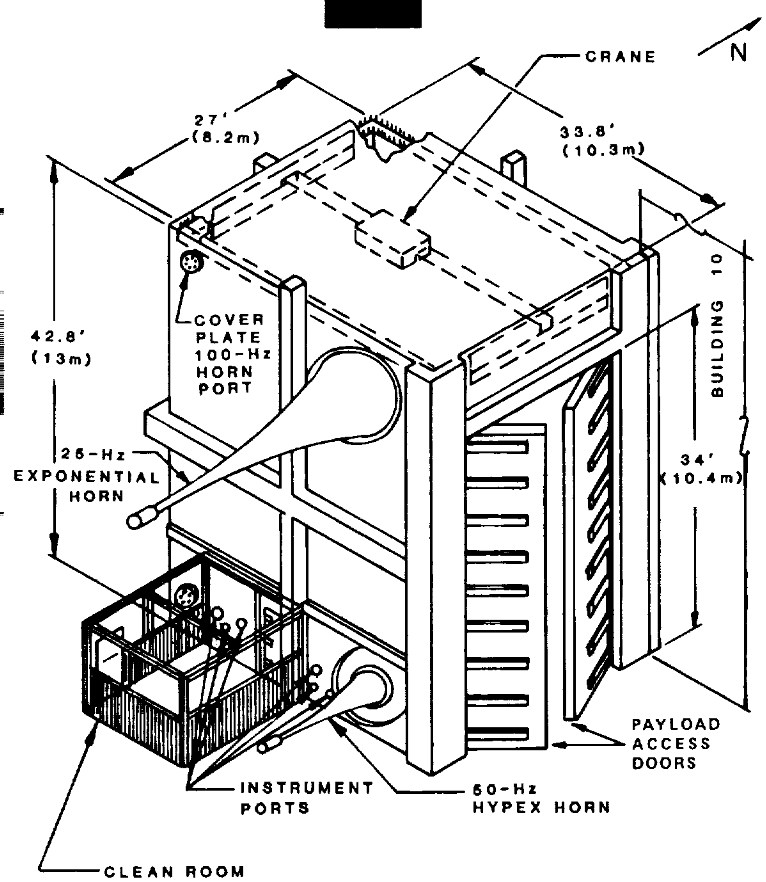


Interior of Acoustic Chamber



Acoustic Chamber Schematic

EMI TEST FACILITIES

DESCRIPTION

There are two electromagnetic interference test facilities available for testing of spacecraft, scientific instruments, and subsystems.

The large shielded room is a class 10,000 clean room, while the smaller one is a standard lab room. Both facilities measure the frequency and amplitude of intentional and spurious emissions produced by the test article, as well as the susceptibility to externally generated emissions. Both radiated and conducted modes of emissions and susceptibility are measured.

MODE OF OPERATION

Signal transducers (electric/magnetic field antennas and split-core line current transformers) convert the radiated and conducted emissions to proportional analog signal line currents. These currents are conveyed, via low-loss cables to console-mounted instruments that detect, amplify, and record the analog currents as voltages in a 50-ohm system.

Use precalculated charts and tables to assist the conversion of the recorded voltages into emission levels for comparison with specification limits.

PARAMETERS

Radiated emissions . . . . 30Hz to 18GHz

Conducted emissions . . . . 30Hz to 100MHz

Radiated susceptibility . . . . 30KHz to 18GHz

Conducted susceptibility . . . . . 30Hz to 400MHz

PHYSICAL CHARACTERISTICS

	Small EMI Room	Large EMI Room
Room Size	28'W x 23'7'L x 10'H	35'W x 63'L x 20'H
Door Size	7'W x 7'3"H	20'W x 19'H
Crane Capacity	N/A	5 ton

INTEGRAL INSTRUMENTATION

Antennas, transducers, amplifiers, signal generators and console-mounted detection and recording systems for use over the frequency range 30Hz to 18GHz.

DATA ACQUISITION

All test data are recorded on either the ELECTRO METRICS FSS-250 or FSS-500 system.

FACILITY INTEGRATION

Ultra low-loss cables that are routed from the instrumentation room to each of the shielded rooms permit recording of signals from antennas and transducers located in either room.

CONTACT – George R. Springham, Code 754.1 (Structural Dynamics & Electromagnetic Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6480.

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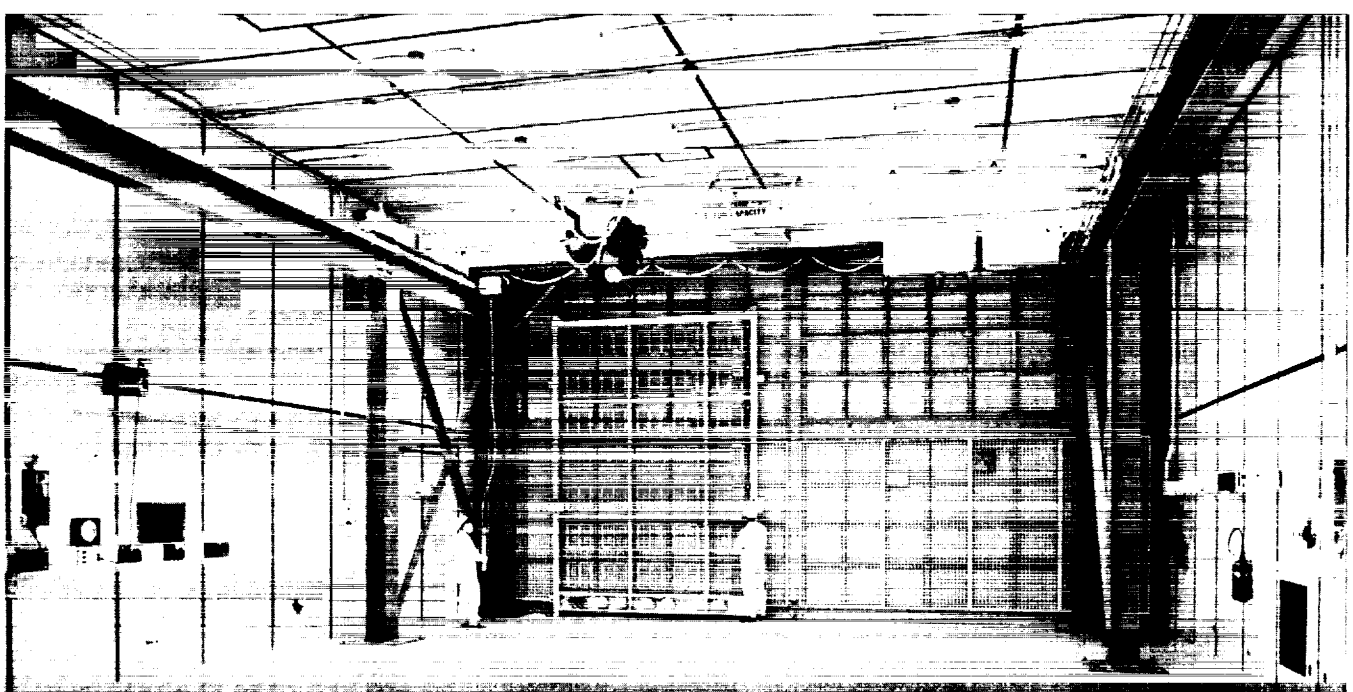
Small EMI-Shielded Room



Large EMI-Shielded Room

SPACE SIMULATION TEST FACILITY

DESCRIPTION

This section summarizes the environmental capabilities and dimensions of selected thermal vacuum test chambers of the Space Simulation Test Facility.

Test volume measurements of each thermal vacuum chamber are the nominal dimensions of the thermal shroud. Evacuation times are for a clean, dry and empty chamber. These data indicate maximum capabilities of a facility. Lesser levels and decreased rates can accommodate payload requirements.

INTEGRAL INSTRUMENTATION

Pressure measurements from ambient to 10^{-3} torr are made with either ALPHATRONS or thermocouple gauges, and from 10^{-3} torr to ultimate with ion gauges. Quartz crystal microbalances, liquid nitrogen condenser plates, and residual gas detectors monitor contamination. Portable thermal control systems control baseplate temperatures to meet special requirements. A variety of penetration plates contain coaxial, multi-pin and liquid/gaseous feedthroughs. Portable clean tents minimize chamber and payload particulate contamination.

CONTACT – Alda D. Simpson, Code 754.4 (Simulation Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6058.

10′ x 15′ SOLAR SIMULATOR THERMAL VACUUM CHAMBER (FACILITY 225)

DESCRIPTION

Facility 225 is a large, horizontal, cylindrically shaped thermal vacuum chamber, suitable for bake out and testing of flight hardware. Electrical feedthroughs, liquid and gas penetrations, and viewports are located at the front, sides and rear of the chamber.

MODE OF OPERATION

Test articles are loaded by crane onto a cart, which is rolled into the chamber on rails. With the door open, the test article is instrumented with thermocouples. A temperature-controlled baseplate may be provided for high thermal dissipation.

PARAMETERS

Solar intensity .... 1 solar constant

Evacuation time (approximately)
atm to 10^{-6} torr .... 3 1/2 hours

PHYSICAL CHARACTERISTICS

Payload support .... wheeled cart (5000 lb capacity)

Viewport .... 12″ dia

COMPARISONS

Nominal Test Volume (dia x L/H)	Type of Chamber*	Facility Number	Operating Pressure (torr)	Temperature Range (°C)	Number of Temperature Channels
10′ x 15′L	SS, DP	225	1×10^{-6}	-190/260	54
7′ x 8′L	DP	237	5×10^{-7}	-190/100	54
12′ x 15′H	CP	238	5×10^{-7}	-190/90	180
7′ x 8′L	CP	239	5×10^{-7}	-190/100	54
3′ x 3′L	DP	240/241	1×10^{-6}	-60/100	12
27′ x 40′H	SS, DP	290	1×10^{-6}	-180/75	300

*SS = Solar Simulation; DP = Diffusion Pumped; CP = Cryopumped

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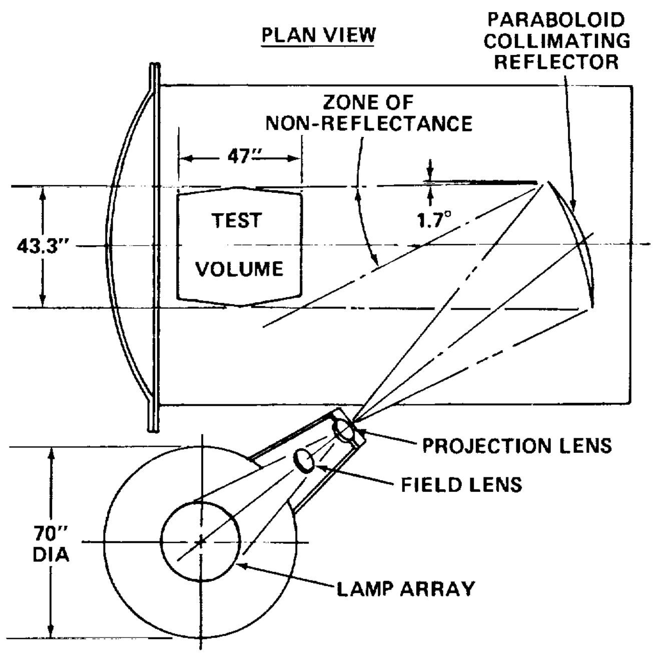


Facility 225

12′ x 15′ CRYOPUMPED THERMAL VACUUM CHAMBER (FACILITY 238)

DESCRIPTION

Facility 238 is a vertical, cylindrical thermal vacuum chamber used for thermal vacuum and thermal balance testing, and bakeout of spacecraft hardware. Electrical feedthroughs, liquid and gas penetrations, and viewports are provided.

MODE OF OPERATION

With the chamber dome rolled back, lower the test article with the crane onto the payload support table. In most cases, special fixturing must be designed due to the uniqueness of the test article support system. Access the chamber through a clean tent to instrument the payload.

To allow off line cool down and regeneration, the cryopumps are isolated from the chamber by sliding gate valves.

PARAMETERS

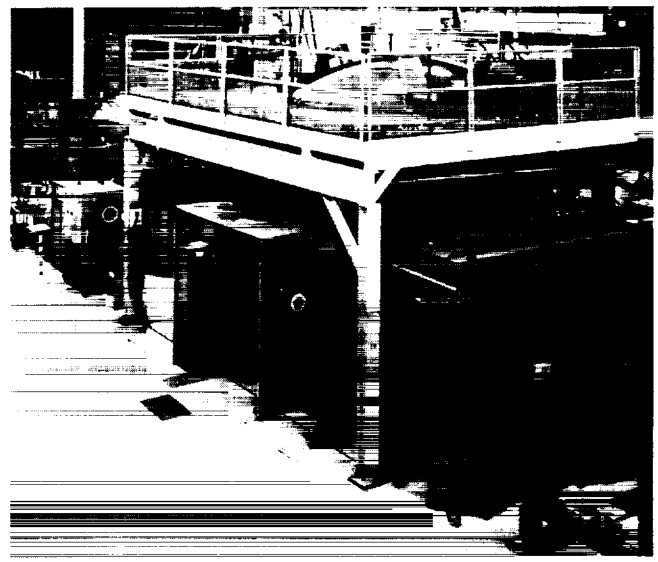
Evacuation time (approximate)
atm to 10^{-6} torr . . . . 4 hours

PHYSICAL CHARACTERISTICS

Payload support table . . . . 4′ x 4′
6 – hard points at floor level
10 – hard points on wall

Crane capacity . . . . 5 ton

Personnel door . . . . 5′ dia



Facility 238

7′ x 8′ THERMAL VACUUM CHAMBERS (FACILITIES 237 AND 239)

DESCRIPTION

These two horizontal, cylindrical chambers are equipped with 12″ diameter viewports to accommodate an external solar simulator. One (Facility 237) is diffusion pumped while the other (Facility 239) is cryopumped. They are used for thermal vacuum and thermal balance testing, and bakeout of test articles.

MODE OF OPERATION

Mount the test article on the portable payload fixture (positioned at the chamber door). After instrumenting the payload with thermocouples, roll the test article into the chamber or suspend from an overhead rail. Connect ground support equipment cabling through the penetration plates.

(Continued)

If desired, accomplish rapid pumpdown (RPD) with auxiliary pumping system. While the pumping systems are being established, a sliding gate valve allows in-chamber operation.

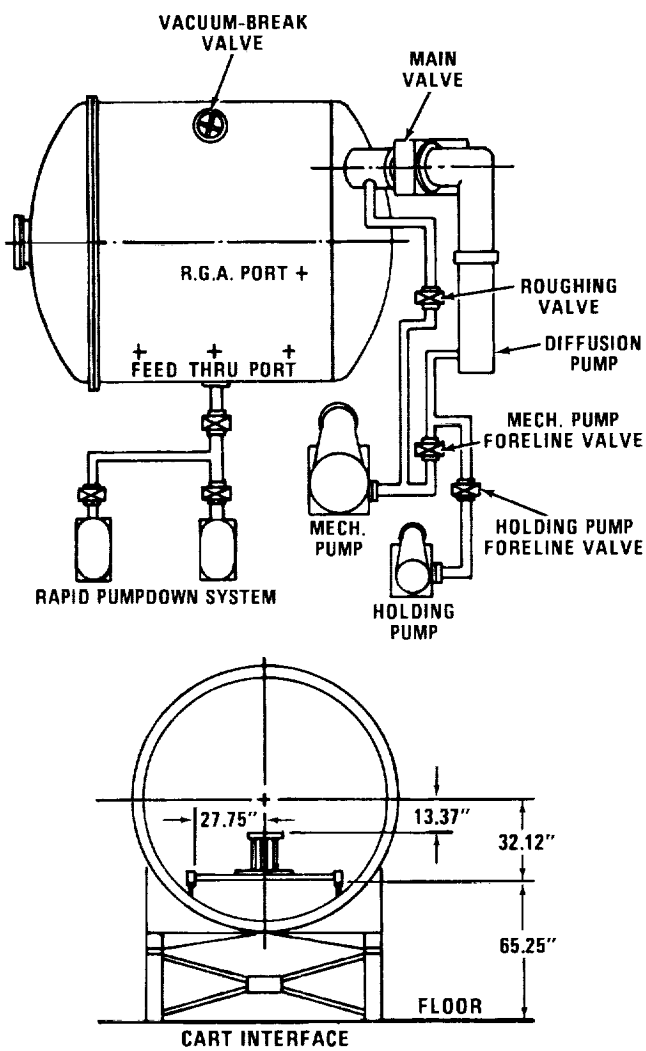
PARAMETERS

Evacuation time w/o RPD (approximately)
atm to 10^{-6} torr .... 5 hours

PHYSICAL CHARACTERISTICS

Gimbal (Optional)
Angle .... ±30° from vertical
Rotational speed .... 0 to 100 RPM

Payload support .... 44" x 44" cart, (1500 lb capacity)



VACUUM SYSTEM

Facility 237

3' x 3' THERMAL VACUUM CHAMBERS (FACILITIES 240 AND 241)

DESCRIPTION

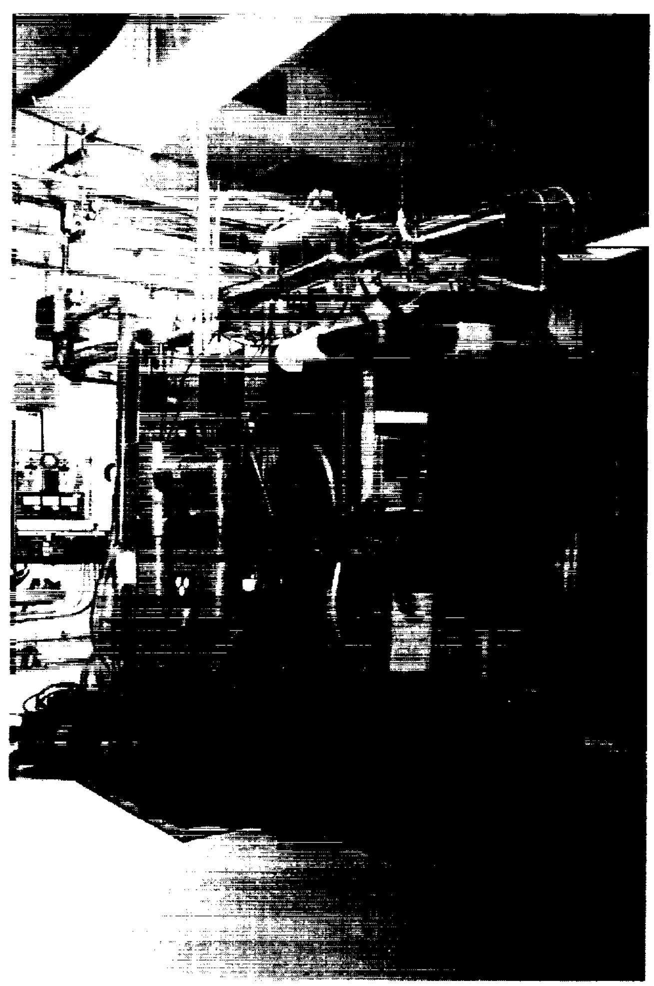
Facilities 240 and 241 are identical horizontal, cylindrical, diffusion pumped chambers which are used for thermal vacuum testing and bakeout of test articles.

MODE OF OPERATION

Place the test articles on a baseplate or suspend from an overhead rail. Instrument with thermocouples and connect ground support equipment cabling through the penetration plates.

PARAMETERS

Evacuation time (approximately)
atm to 10^{-6} torr .... 60 min



Facility 240

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27' x 40' SOLAR VACUUM CHAMBER (FACILITY 290)

DESCRIPTION

Facility 290 is a top loading, very large space environment test thermal vacuum chamber used for solar/thermal testing and bakeout of complete spacecraft. Chamber evacuation is provided by mechanical pumps, blowers, and oil diffusion pumps. The chamber is also equipped with a helium cryopump which operates at 18°K.

Thermal control is provided by aluminum tube-in-sheet cylindrical shroud sections with both liquid nitrogen and gaseous nitrogen operational modes. A payload support gimbal with multiple rotational axes has a separate thermal control system.

Resistance heater arrays with external power supplies or gaseous nitrogen panels are available for custom thermal requirements. The chamber is also equipped with a uniform solar beam, adjustable in both intensity and diameter.

MODE OF OPERATION

With the chamber dome rolled back, load the test article onto the payload table or internal fixturing. An external air supply provides clean air (class 10,000) to the chamber during pretest activities. To instrument the test article with thermocouples, connect ground support equipment cabling, and install hardware, enter the chamber through a cleanroom air shower at the personnel door.

PARAMETERS

Evacuation time (approximate)
atm to 10^{-6} torr . . . . 4 hours

PHYSICAL CHARACTERISTICS

Payload support . . . . 20,000 lb

Viewport . . . . 12" dia

Standard electrical feedthroughs

Number	Connectors
62	37 pins
6	7 pins
16	4 pins

Gimbal

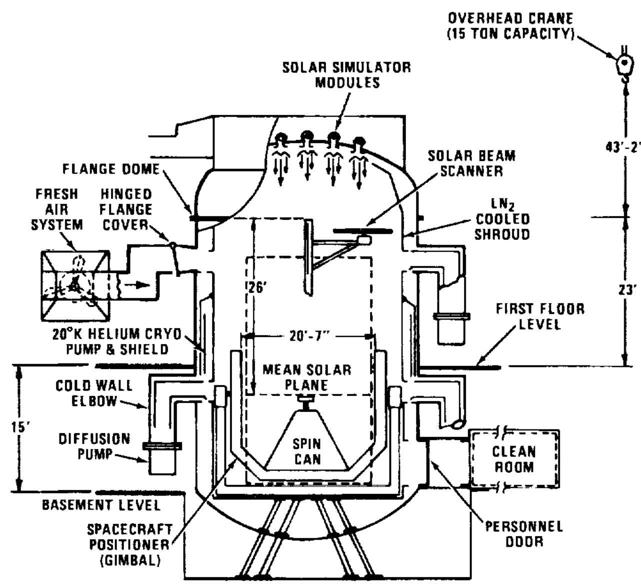
Load . . . . 4500 pounds (C.G. at pitch axis)

Tilt angle . . . . ±155°

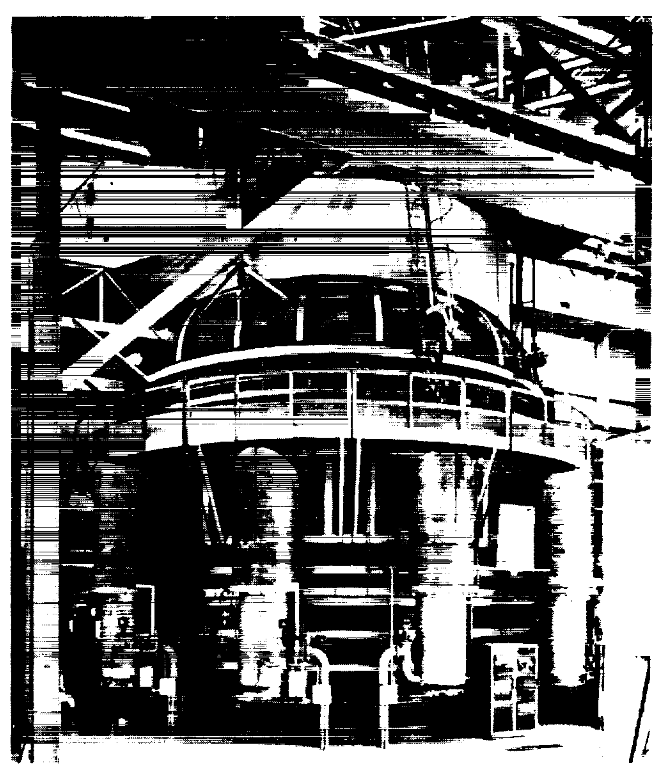
Slip rings . . . . 4 coax, 17 power, 88 thermocouple or thermistor

Spin can load . . . . 1500 ft-lb, maximum moment

Rotation . . . . 0–80 RPM either direction



Solar Vacuum Chamber (Facility 290)



Facility 290

STATIC/DYNAMIC BALANCE FACILITY

DESCRIPTION

The Static/Dynamic Balance Facility provides dynamic and static balancing of aerospace vehicles and components. The facility also determines weight, moments of inertia, and locates the center of gravity. Due to the explosive nature of rocket motors, the facility is at an isolated location on Wallops Island.

MODE OF OPERATION

Units to be tested are placed on the appropriate machine. Because of the explosive nature of rocket motors, the two test buildings are 800 feet apart with the control center located between the two buildings. Personnel in the Control Center are in continuous contact over several communication systems (including CCTV). All buildings are heated, air conditioned and humidity controlled. Test areas are slightly pressurized to prevent atmospheric contamination.

Safety precautions are foremost. In addition to the communications and remote control capabilities, there is a traffic warning system and a safety console system. Only 8 people are allowed in the test areas during set up of hazardous operations. The test area is evacuated of personnel prior to spin-up.

Dynamic and static balancing is done on one of 4 major machines in the 2 test areas: the vertical SCHENK TREBEL balancer, and the 3 vertical GISHOLT balancers. All are remotely operated and monitored from the Control Center.

PARAMETERS FOR LAUNCH VEHICLES

(all machines)

Weight of workpiece	10–35,000 lb
Maximum diameter	14′
Maximum height	28′
Balance speed	30–1000 RPM

The balancing machines give a direct readout of:

- static unbalance (C.G. offset),
- couple unbalance (products of inertia), and
- dynamic unbalance (combination C.G. offset and products of inertia).

The sensitivity of the balance machines is within the range required for rocket vehicle components, using the formula: We = ur, where:

W = weight (ounces) of test object
e = distance (μ inches) between geometric center line and primary inertia axis
u = unbalance (ounces)
r = radius (inches) in which unbalance is located

Balancing quality of 10–25 μ inches is obtained.

PHYSICAL CHARACTERISTICS

Test Bay #1, Bldg. V-45

Size	60′W x 80′L x 30′H
Lift capacity	20,000 lb

Test Bay #2, Bldg. V-55

Size	40′W x 60′L x 40′H
Lift capacity	35,000 lb

INTEGRAL INSTRUMENTATION

The remote Control Center is made of blast-resistant construction and contains:

SENCORE Model SC61 Wave Form Analyzer

SENCORE Model LC53 Capacitance/Inductance Analyzer

Digital Multimeter

Tachometer/Rate Meters

Optical Alignment equipment

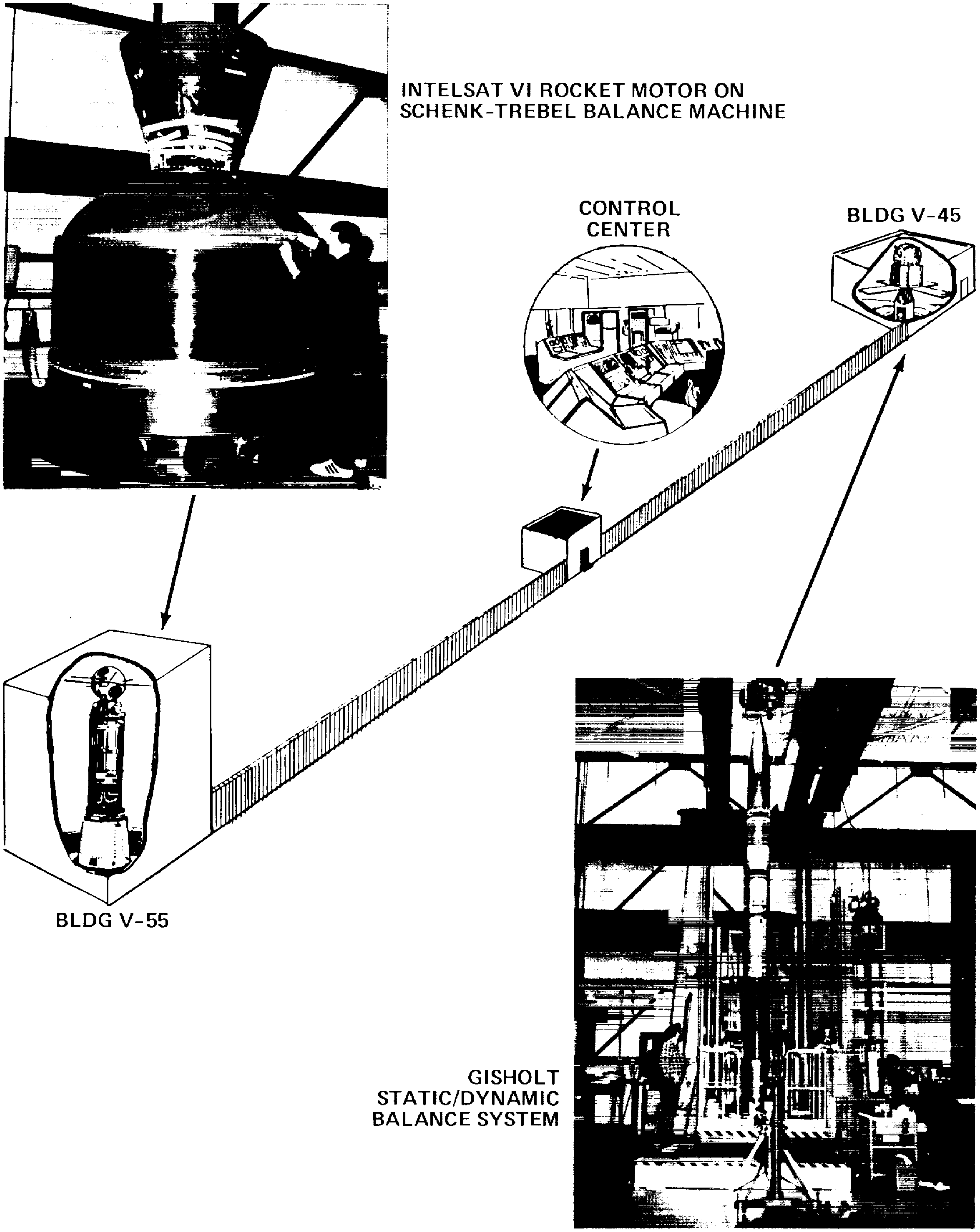
DATA ACQUISITION CAPABILITIES

Data is obtained with internal system readout, HP-97 programmable calculators, and a GILMAN/GISHOLT BP 2020 microprocessor/balance analyzer. Data quality is assured by test methodology, maintenance procedures, quality assurance, data printout, and data documentation.

REFERENCE

Operation is based on the theory and practices of experts in balancing and mass properties measurements, *e.g.*, N.C. Schaller, J. M. Lewallen, and William E. Lang (GSFC/Greenbelt), Doug Stadelbauer (SCHENK-TREBEL), Richard Boynton (SPACE ELECTRONICS, INC).

CONTACT – Dave Ward, Code 834.3 (Test & Evaluation Section), NASA Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, VA 23337, 804-824-1000.



Static/Dynamic Balance Facility

HIGH SPEED CENTRIFUGE FACILITY

DESCRIPTION

The SCHAEVITZ M-2-A High Speed Centrifuge is a spin table that can subject small instruments to steady-state acceleration. A remotely located drive console controls spin table speed.

For operational safety, the spin table is in a controlled access area. Three sides, ceiling and floor of the spin table enclosure are reinforced concrete. The access side is a removable, steel-clad, wooden barricade.

MODE OF OPERATION

Standard testing procedure includes these steps:

- Mount payload on one side of the spin table fixture and counterbalance with dummy weights on the other side.
- Wheel barricade into place to protect personnel. Set up CCTV to permit viewing the payload from the control console.
- Determine acceleration levels by measuring the radius and calculating the RPM needed for specific levels. Adjust RPM level at the control console and measure with a precision digital frequency counter.

PARAMETERS

Acceleration range	0 to 1000 g
Load range	0 to 5000 g-lb
Payload size	12" cube
Payload weight (max)	5 lb
Test radius (nominal)	11.5"
Table speed	0 to 1800 RPM

PHYSICAL CHARACTERISTICS

Spin table enclosure	68"L x 68"W x 65"H

INTEGRAL INSTRUMENTATION

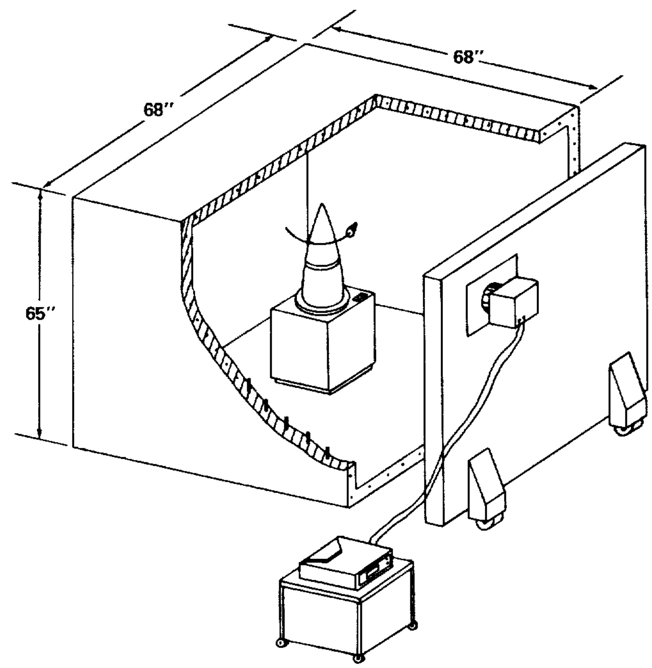
The Control Console contains analog meters to measure table speed in RPM, drive motor armature current (DC amp) and voltage (DC volt). A digital frequency counter measures RPM.

DATA ACQUISITION

Instrumentation	12 slip rings, 5 amp, 220 V
Power	3 slip rings, 20 amp, 280 V

NOTES

Pyrotechnic squibs on the payload can be fired via the 3 power slip rings.



High Speed Centrifuge

CONTACT – George R. Springham, Jr., Code 754.1 (Structural Dynamics & Electromagnetic Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6480.

COATING
AND
PLATING

OPTICAL THIN FILM DEPOSITION FACILITY

DESCRIPTION

The Optical Thin Film Deposition Facility develops and evaluates special purpose single and multilayer thin films and applies them to various substrates for use in aerospace instruments, laboratory equipment, and spacecraft hardware.

MODE OF OPERATION

- Inspect substrate before and after each step.
- Strip existing coating (where appropriate).
- Check fit substrate in holding fixture with witness sample. Remove and clean substrate and witness sample.
- Place substrate and witness sample into holding fixture and place in high vacuum vessel.
- Load evaporation sources and align monitoring system.
- Pump down vessel and make deposition.
- Vent vacuum vessel and remove substrate and holding fixture.
- Measure witness sample and package optics for shipping.

PARAMETERS

Vacuum Deposition Systems

	80″	42″	42″(*)	18″
Pressure (torr)	9×10^{-7}	10^{-6}	5×10^{-8}	10^{-6}
Resistance heat source	yes	yes	yes	yes
Substrate heater	quartz	infrared		
Thickness monitor	yes	yes	yes	yes
Optical monitor	1216Å	visible		visible
Electron beam gun	yes			

(*)cryo-pumped: equipped with automatic process controller and automatic deposition rate controller; housed in a 34′ x 13′ class 100,000 clean room with gravity and mechanical convection ovens, and chemical fume hood.

INTEGRAL INSTRUMENTATION

Optical systems check coating parameters, *e.g.*, reflectivity, transmission, physical thickness and optical thickness. Equipment includes: angstrometers, spectrometers, quartz crystal oscillators, modulated beam photometers and a Lyman-Alpha monitoring system.

DATA ACQUISITION

Test data, test procedures, special setups and fixturing are maintained in written logs. A chart recorder employed during each deposition process records the optical characteristics and/or physical thickness of the thin film.

NOTES

A study is in progress to determine the feasibility of converting all vacuum coaters from diffusion pumps to cryopumps, with automatic process and deposition controls. If conversion is made, all systems would be tied to a central computer.

REFERENCES

"Vacuum Evaporation Method for Manufacturing Neutral Density Filters and Non-linear Density Profiles," *Applied Optics*, 1973.

"Lithium Flouride Protected Aluminum Reflectance Coatings for Ultraviolet Space Optics," paper presented at the 1973 Optical Society of America convention, New York.

"Effects of Irradiation on the Reflectance of Silicon Oxide Protected Aluminum in the Far U.V.," *Applied Optics*, 1978.

CONTACT – Linda Miner or George Bergen, Code 717.2 (Optical Thin Film Deposition Facility), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-8200

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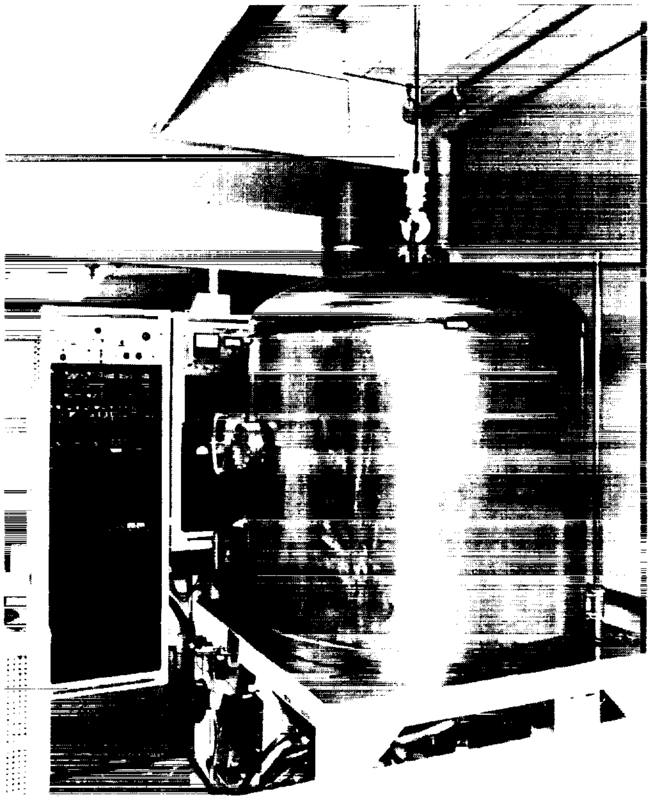
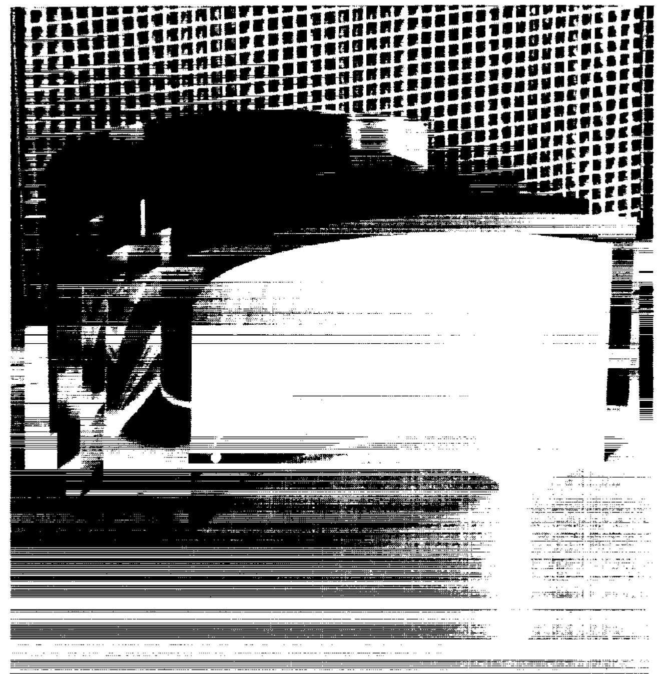
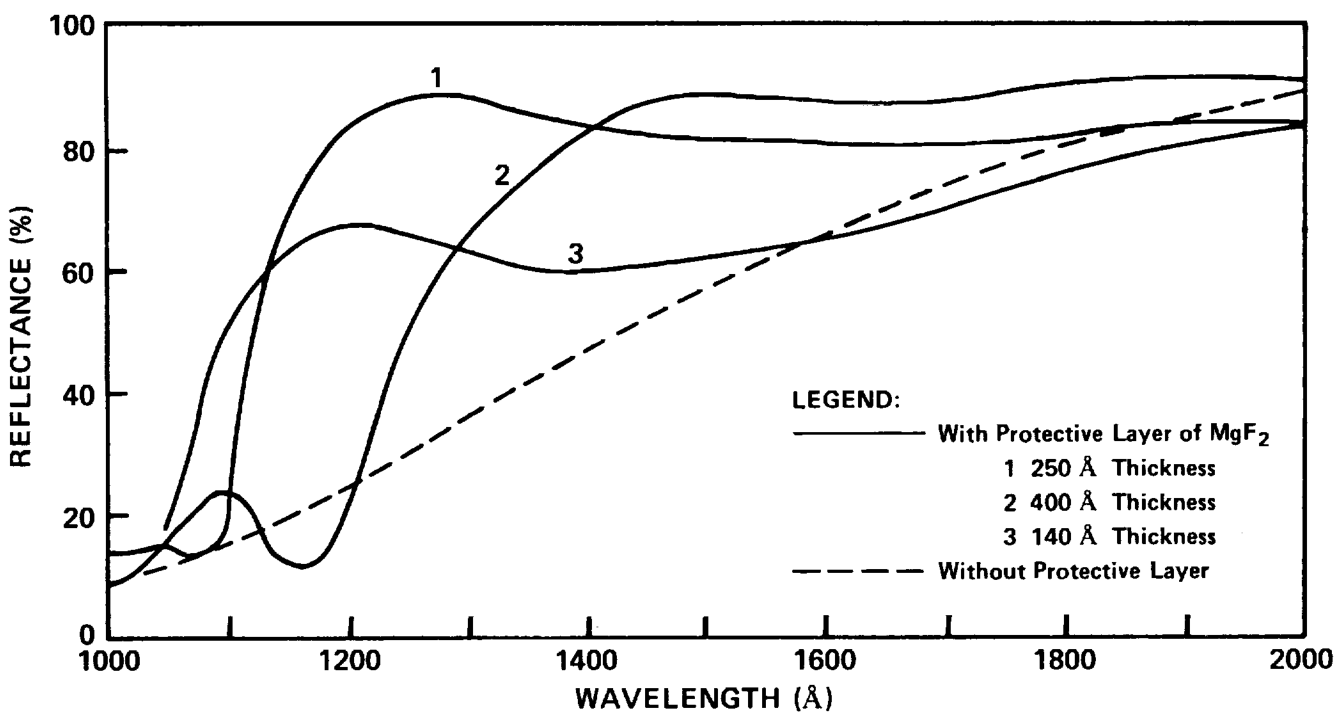


42" Deposition Chamber



BBXRT Flight Mirror Segments



Reflectance of Evaporated Al With and Without Protective Layers of MgF_2

GOLD PLATING FACILITY

DESCRIPTION

Using an electro-chemical deposition process, the Gold Plating Facility plates 24K gold on aluminum, copper, BeCu, stainless steel and invar.

Gold plating provides uniform, bright deposits with several desirable characteristics, *e.g.*, relatively hard (yet ductile), excellent solderability, non-crystalline structure, and superior electrical integrity (because of lack of organic films).

MODE OF OPERATION

The actual step-by-step procedure depends on the material being plated. However, all gold plating follows these steps:

- Degrease the part with a chlorinated hydrocarbon vapor solvent.
- Remove physical soils in an ultrasonic cleaning bath.
- Remove metal-oxide films using an activation process.
- Deposit a "strike" (thin metal coating) on the part to improve adhesion of the gold plating.
- Deposit a strike of gold to prevent contamination of the pure gold bath.
- Gold plate the part in the 60 or 205-gallon bath.
- Between every step of the plating procedure, rinse the part in a water bath.

INTEGRAL INSTRUMENTATION

KOCOUR hull cell for bath control and plating thickness tester.

REFERENCE

Mil-G45204 B, Amendment 2, Type IC G IIC
ASTM Standard Specification for Electrodeposited Coating of Gold, B-488-80.

CONTACT – John Henninger, Code 752 (Fabrication Engineering Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-5545.

PARAMETERS

	AUROBOND TN	BDT 510
	Gold Strike Bath	Gold Bath
Metallic gold content	0.2 tr oz/gal	1.0 tr oz/gal
pH	3.5	8.5
Specific gravity	15° Baume	10° Baume
Temperature	130° F	120° F
Anode	gold-plated PLATANIUM	gold-plated PLATANIUM
Anode:Cathode ratio	2:1	2:1, or higher
Plating rate	N/A	120 milligram/amp
Time to deposit	15 - 60 sec.	13 min to deposit 0.0001 inch

PHYSICAL CHARACTERISTICS

	AUROBOND TM		
	Gold Strike Bath	BDT 510	Gold Baths
Solution vol (gal)	22	60	205
Size (L, W, depth)	24" x 15" x 17"	30" x 24" x 24"	44" x 36" x 36"
Output current (max. DC)	10 amp, 10 volt	10 amp, 15 volt	50 amp, 12 volt
Agitation	moderate	vigorous	vigorous

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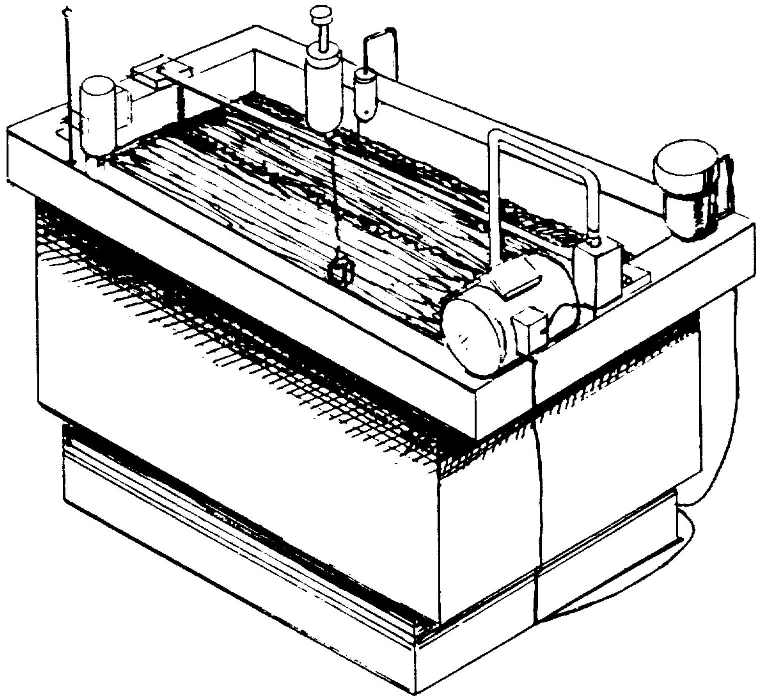
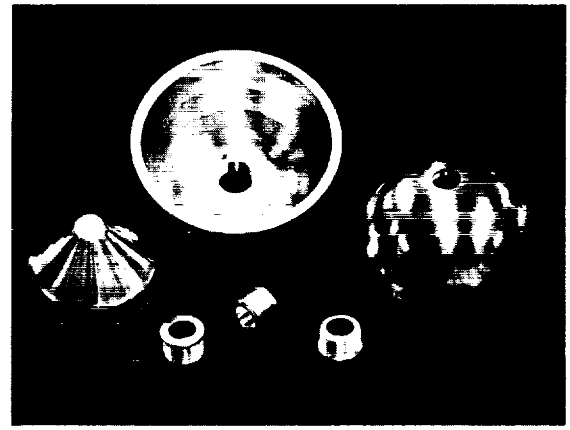
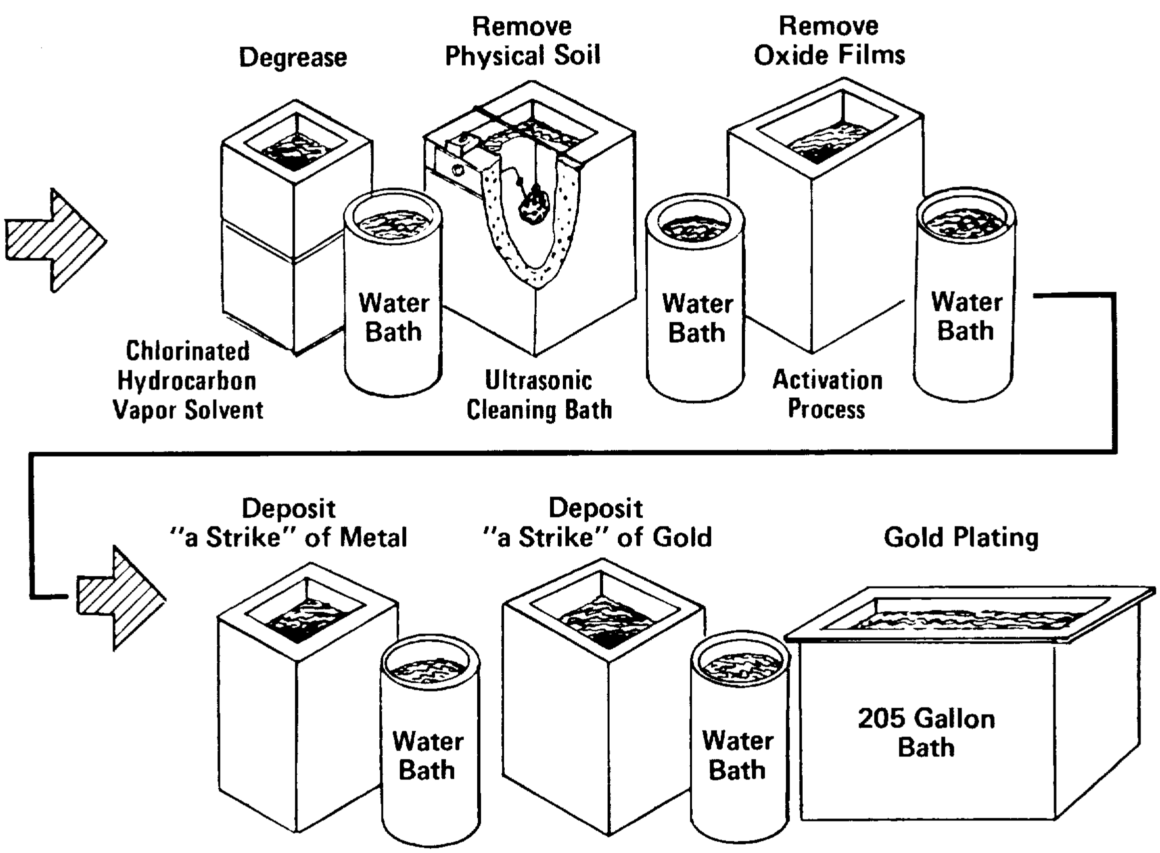


60 Gallon Gold Plating Tank



Gold Plated Articles



Gold Plating Process

PAINT FORMULATION & APPLICATION LABORATORY

DESCRIPTION

The Paint Formulation & Application Laboratory formulates and applies space flight-qualified organic and inorganic coatings. The lab is in two parts, one primarily for formulation, the other for application. Specimens up to 15′L x 6′W x 6′H are coated.

Thermal control and electrically conductive coatings, either organic or inorganic, have solar absorptances ranging from 0.17 to 0.96.

Optical reference standard coatings, either organic or inorganic, have absorptions ranging from 2.79% (optical integrating sphere coatings) to 8.22% (primarily exterior coatings).

The latest innovation in optical coatings are water-resistant coatings with absorptions of 8.2% for in-field use.

PARAMETERS

Thermal Cont. & Elec. Conduc. Coatings

Colors . . . . white, yellow, green, black
Electroconductivity
(varies with color) . . . . . 10^3 to 10^5 ohm/m^2

Outgassing properties:

Total mass loss . . . . 0.70% - 4.36%
Volatile condensible material . . . . up to 0.14%

Optical Reference Standard Coatings

Outgassing properties:

Total mass loss . . . . 0.14% - 0.75%
Volatile condensible material . . 0.01% - 0.10%

PHYSICAL CHARACTERISTICS

Thermal Cont. & Elec. Conduc. Coatings

After 5000 sun hours on IMP–H and OSO–H spacecraft, the MS74 white thermal control paint indicated a change of 0.01% solar absorptance, extrapolated from temperature measurements.

After 5 years, the electrically conductive thermal control coatings *i.e.*, NS43C, NS43E, NS53B, NS55F and NS59A, flown on ISEE A, B and C spacecraft indicated a change of 0.035% solar absorptance, extrapolated from measured temperatures.

Optical Reference Standard Coatings

Coatings are used on delicate laboratory equipment, satellite and balloon flights, and in-field reference standards, *e.g.*, LANDSAT.

REFERENCES

Cyrus Butner, John B. Schutt and M. C. Shai, "Comparison of the Reflective Characteristics of Polytetraflouroethylene and Barium Sulfate Paints," *Applied Optics*, Volume 23, Page 1139 (April 15, 1984).

Michael C. Shai, *Formulation of Electrically Conductive Thermal Control Coatings*, NASA Technical Paper 1218, April 1978.

M. C. Shai and John B. Schutt, *Formulation Procedure and Spectral Data for a Highly Reflective Coating from 200nm to 2300nm*, NASA Document X-762-71-266, July 1971.

CONTACT – Jule Hirschfield, Code 754.2 (Radiation Simulation & Thermal Control Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6201.

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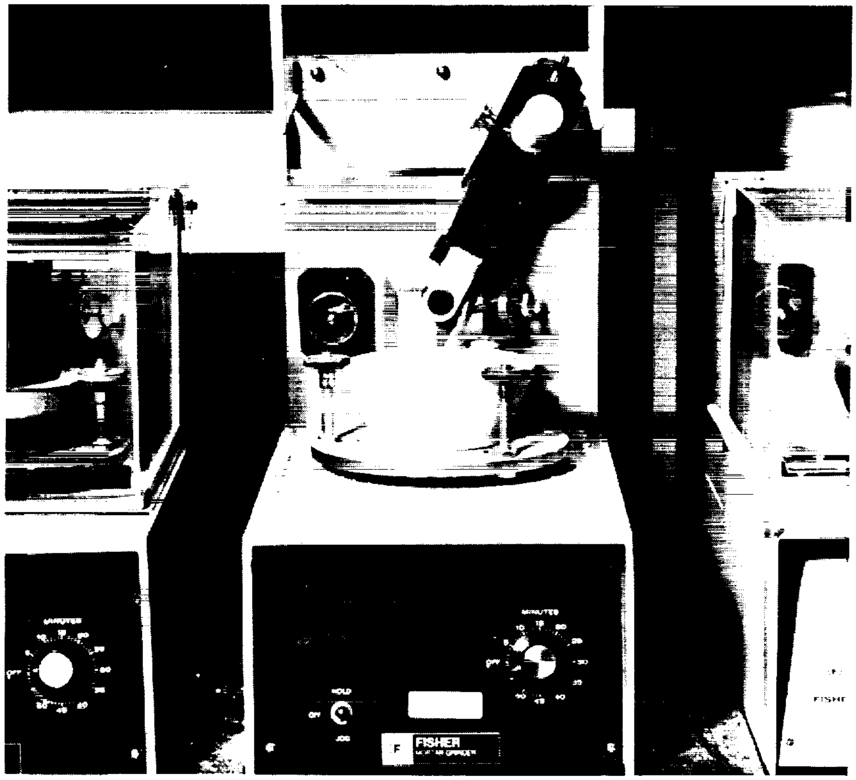
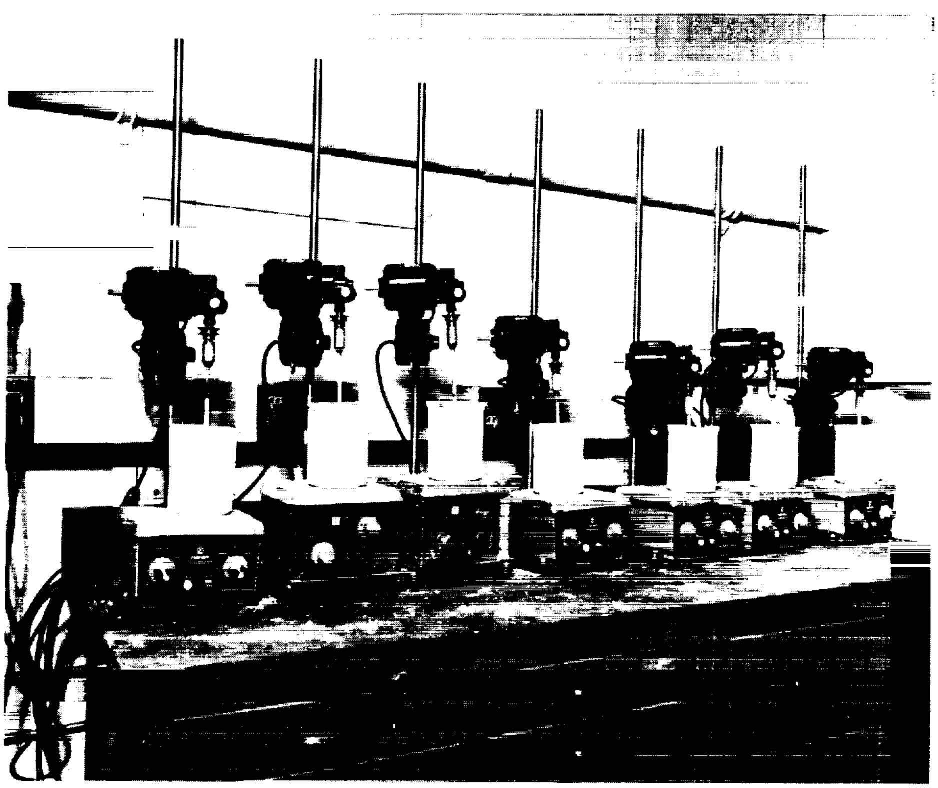


Automatic Pestle



Formula Mixing Stations

RESEARCH

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PROPULSION RESEARCH FACILITY

DESCRIPTION

The Propulsion Research Facility conducts hazardous tests, including firing satellite thrusters, testing pneumatic components (valves and regulators), proof and leak tests of high pressure systems, preparing and operating propellant loading GSE, performing propellant chemical analyses, and conducting tests with cryogens.

MODE OF OPERATION

For pneumatic components, clean to rigid specifications and test for serviceability, accuracy of calibration, proof pressure and leak tightness. Integrate the systems in a 10,000 class clean room. Inspect for cleanliness, serviceability, and leak tightness.

PARAMETERS

Vacuum Chambers

	8′ x 8′	3′ x 5′	3′ x 5′
Ultimate vacuum (torr)	10^{-3}	10^{-3}	10^{-7}
Thermal shroud temperature range	-170°C to 150°C	N/A	-170°C to 150°C

Environmental Chamber

Temperature . . . . -170°C to 150°C (±1°C)

Humidity . . . . 0 - 100%

Vacuum Bell Jar System

Ultimate vacuum . . . . 10^{-8} torr

DATA ACQUISITION CAPABILITIES

30 temperature/voltage measuring channels
32 status out/command channels
32 status input channels
1 32-bit parallel input digital channel
2 FLUKE Model 1722A instrument controllers
1 10–megabyte hard disk
1 8-channel digitizing recorder

PHYSICAL CHARACTERISTICS

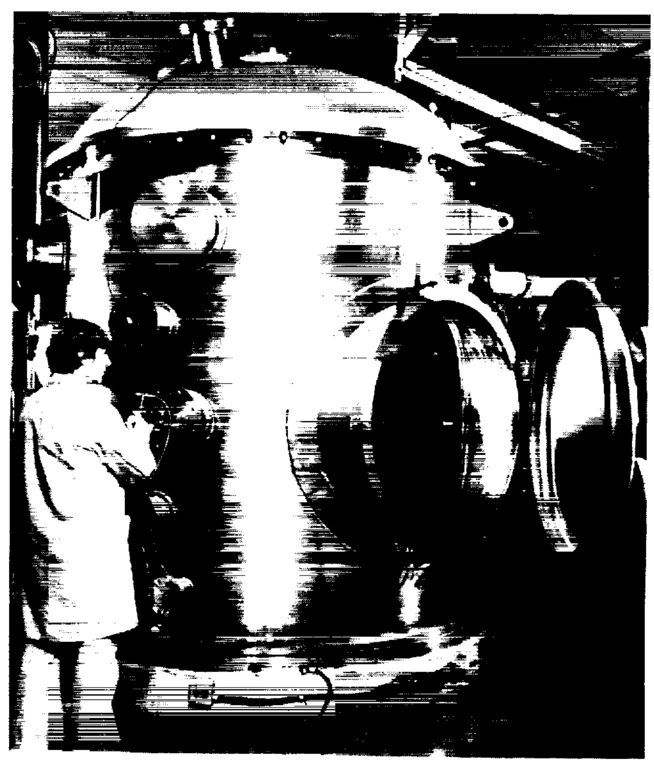
Satellite thrusters are tested in the 8′ x 8′ vacuum chamber with shroud stack controller. **Pneumatic components and systems** are tested in a 3′ x 5′ vacuum chamber with shroud and stack controller. They are proof and leak tested with a He leak detector.

The facility has machine shop, 10,000 class clean room, separate assembly labs for system integration, and a chemistry lab.

INTEGRAL INSTRUMENTATION

Instrumentation for vacuum chambers and vacuum bell jar system, environmental chamber, He leak detector, and chemistry lab (gas chromatograph, automatic titrator, atomic absorption spectrophotometer, and UV visible spectrophotometer).

CONTACT – Gary Langford, Code 713.3 (Fluid and Hazardous Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-8664.



8′ x 8′ Vacuum Test Chamber

ROCKET LAUNCH
AND
TRACKING

WALLOPS RANGE FACILITY

DESCRIPTION

The Wallops Range Facility is an instrumented test range consisting of integrated mainland and island facilities for conducting research missions using:

- rocket-propelled vehicles both orbital and suborbital,
- aircraft, and
- balloons.

The facility prepares, tests, and launches solid fuel rocket systems and their payloads, and then tracks, and records trajectory and scientific data. The Atlantic Ocean and airspace above is the test range. The range area used for a given test is flexible and tailored to meet requirements of individual missions.

LAUNCH FACILITY

The Wallops Island Launch Facility is comprised of 5 launch pads, 2 launch blockhouses, and 15 assembly bays to support the preparation and launching of orbital and atmospheric sounding rockets.

MODE OF OPERATION

Receive, inspect and modify rocket motors, adapters, and associated pyrotechnics in component form. Integrate components into system configuration to support requirements of diverse scientific missions.

Use array of launchers ranging in size from the test rocket launcher accommodating the 2.75-inch diameter x 38" length test rocket weighing approximately 12 lbs., up through the SCOUT launcher that supports the 45" diameter x 72' long SCOUT rocket weighing approximately 47K lb.

These launchers range in complexity from a manually-operated vertical tube to remote-controlled launchers with removable environmentally-controlled shelters.

PARAMETERS

Types of launchers and size of rocket each launcher accommodates:

ARCAS – Specifically designed for single-stage ARCAS rocket motors. Favorable characteristics of this rocket motor: provides a soft, slow flight for delicate and sensitive instruments (approx. 3,200 FPS at burnout).

REAR ATTACHED GRIP (RAG) – Local and remote control and readout system. Fitted with twin meteorological rocket launchers. Can be adapted to handle Nike sized rockets.

HIGH ALTITUDE DIAGNOSTIC (HAD) – 30' rail. Local and remote (5K lb capability) versatility from single stage vehicle up to and including 3 stages, *e.g.*, Taurus Nike Tomahawk.

ASTRO MET LAUNCHER (AML) – 18' 18" rail. Twin boom to accommodate single and multi-stage vehicles up to 3K lb. Local and remote control.

ATLANTIC RESEARCH CORPORATION (ARC) – 44' 6" rail. Local and remote control, plus environmental shelter with capability of launching 3-stage vehicles, *e.g.*, BLACK BRANT X (BLACK BRANT V, TAURUS, NIHKA) weighing up to approximately 6.5K lb.

TUBULAR – Local and remote control capable of launching a 4-stage vehicle, *e.g.*, ATHENA rocket. Capacity is approximately 10K lb.

SCOUT – Launcher with environmental shelter (semi clean room). SCOUT rocket can orbit 500 lb payload into a 500 mile circular orbit.

RADAR

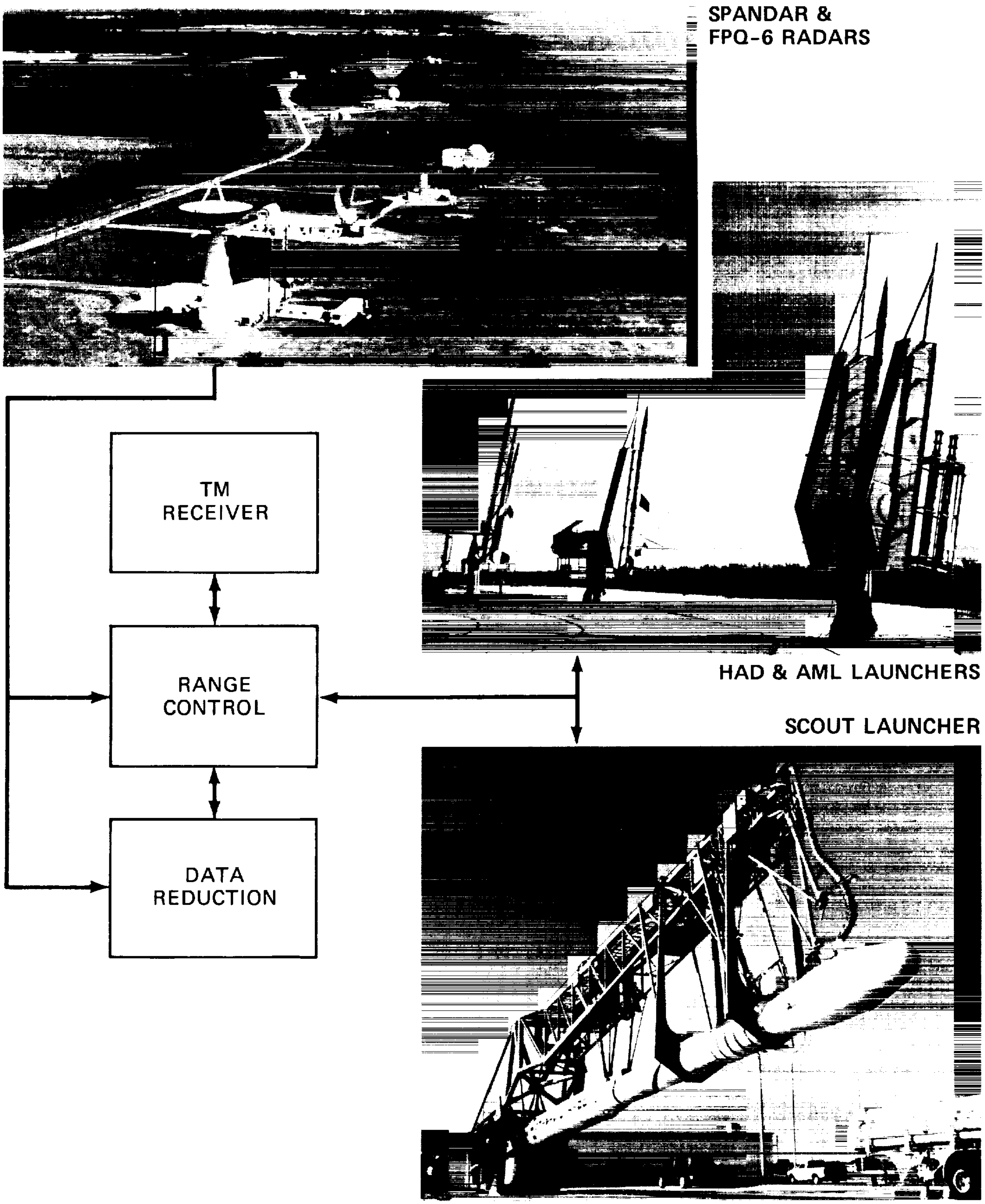
Radar facilities include fixed and mobile radar and data recording systems for tracking space targets. Three high precision C-band radars, one FPQ-6, and 2 FPS-16 radars form the heart of the radar system.

These systems track a variety of targets, from low altitude balloons to high altitude sounding rockets and orbital vehicles.

These radars are capable of skin or transponder track. They provide detailed trajectory data (on magnetic tape) and quick-look trajectory data (on plotboards and a TV graphics system).

A slaving system interconnects the radars, such that if one radar is tracking the desired target, it can electronically aid the other radars in target acquisition.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



Wallops Range Facility

WALLOPS RANGE FACILITY

TELEMETRY

Wallops Flight Facility has a complete telemetry station for providing data in the 1435–1535 MHz (L band) and 2200–2300 MHz (S band) frequency bands.

The station consists of two 24′ antenna systems, two 8′ antenna systems, ground receiving equipment, magnetic tape recording systems, monitoring equipment, and a data analysis station made up of discriminators, decommutators, PCM decoders, and paper recorders.

These systems track aircraft, balloons, or rockets that carry an L or S band transmitter.

PHOTOGRAPHIC & OPTICAL

Photographic and optical facilities include data recording, tracking, aerial, documentary, high-speed, time-lapse, and other photographic techniques to detect, record and measure various phenomena.

These photographic & optical capabilities provide documentation of all rocket launch sequences, including medium- and high-speed tracking coverage of vehicle flight, sequential coverage of vehicle lift-off, and still and motion picture documentary coverage of the vehicle preparation and assembly.

Photographic and optical data acquisition systems are used for several research projects. Infrared scanners and multispectral cameras, mounted in aircraft, acquire data of the earth's surface for the study of agriculture, oceanography and other ecological phenomena.

COMMUNICATION

Communications facilities include point-to-point, air-to-ground, ship-to-shore, and intrastation systems. These include tie cables, microwave links, cable plant systems, closed-circuit television systems, command/destruct systems, frequency shift tone keying systems, operational intercommunications systems, and the NASCOM system.

Radio equipment is available in the HF, VHF, and UHF frequency bands. RF support includes spectrum management, frequency monitoring and interface control.

METEOROLOGICAL DATA

The weather station provides detailed weather forecasts, surface weather monitoring, and upper air weather balloons.

CONTACT – Cary Milliner, Code 830 (Wallops Operation Division), NASA Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, VA 23337, 804-824-1332.

INSTRUMENT ASSEMBLY
AND
ALIGNMENT

OPTICAL INSTRUMENT ASSEMBLY & TEST FACILITY

DESCRIPTION

Calibration, Integration & Alignment (CIA) Facility

The Calibration, Integration and Alignment Facility is a large multi-function test area. The room is a horizontal, laminar flow, class 10,000 clean room utilizing HEPA filtered air, with exceptional temperature and dew point control suitable for astronomical instruments.

Integration or buildup of large optical instruments, spacecraft, components, or arrays can be accomplished at one end of the room, where a 135-ton concrete isolation block is located and evaluation of cryogenic experiments can also be performed in a helium dewar within the area.

The Optical Alignment Facility (OAF) is at the other end of the room on a 250-ton concrete isolation block. The OAF consists of a remotely controlled, precision rotary table on which the test object is located, a vertical tooling bar for a first-order theodolite, an overhead structure for locating relay mirrors and an elevator to enable operators to position the theodolite at any height.

OPTICAL SUPPORT FACILITIES

These facilities include 3 optical laboratories with multiple isolation tables and clean tent capability for class 10,000 conditions. The laboratories support assembly and testing of optical instruments and components. Techniques used range from optical through interferometric testing and image analysis.

MODE OF OPERATION

Optical metrology measurements support environmental testing of spacecraft, instruments, and subassemblies. Optical assembly and testing techniques are used to build and evaluate optical instruments from engineering models through flight units.

PHYSICAL CHARACTERISTICS

Calibration, Integration & Alignment Facility

Clean room	class 10,000
Air Velocity	90 ± 20 fpm
Temperature	23 ± 2°C
Room size	72′L x 24′W x 50′H
Crane capacity	7.5 ton
Hook height	44′

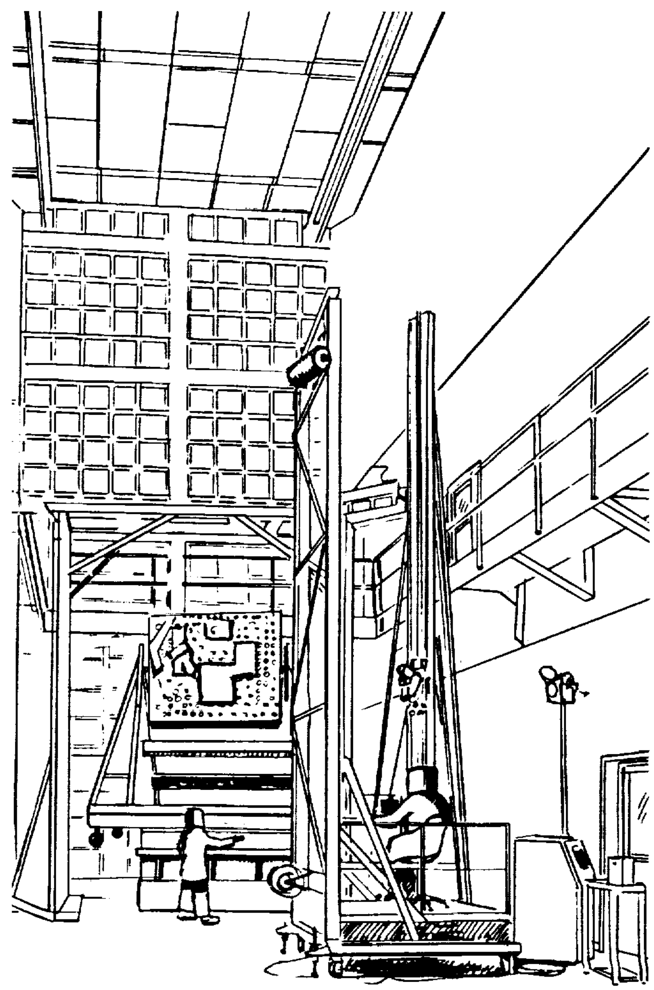
Optical Alignment Facility

Rotary table	7′ dia
Maximum test item weight	3 ton
Maximum test item height	22′

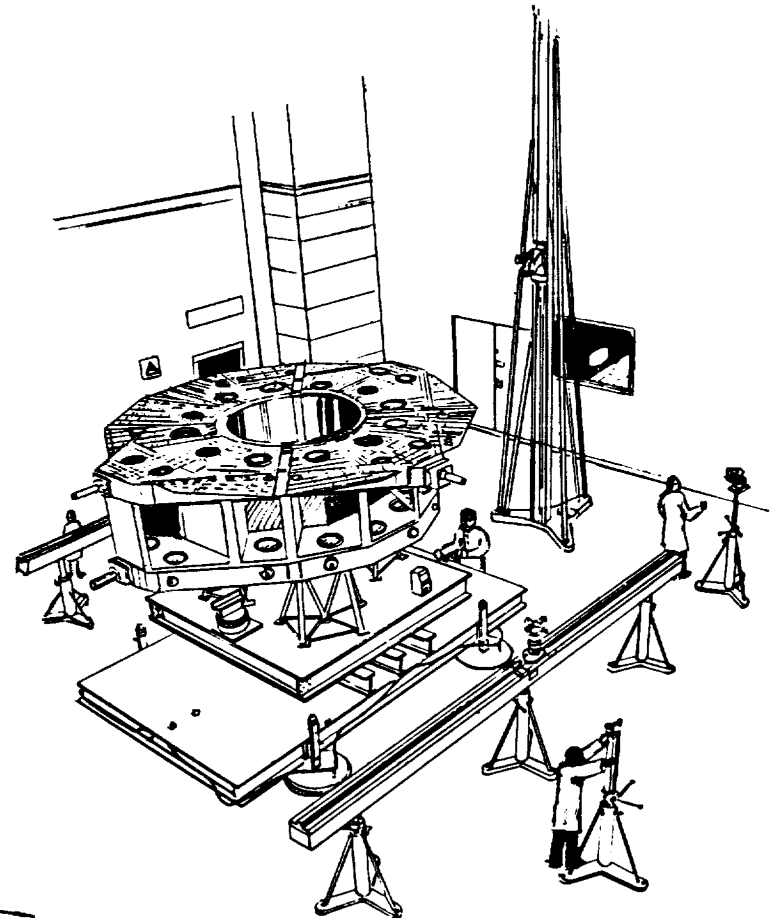
INTEGRAL INSTRUMENTATION

First-order theodolites, autocollimators, collimators, phase measuring interferometer, photogrammetry equipment, precision rotary tables, dark room, and granite isolation tables.

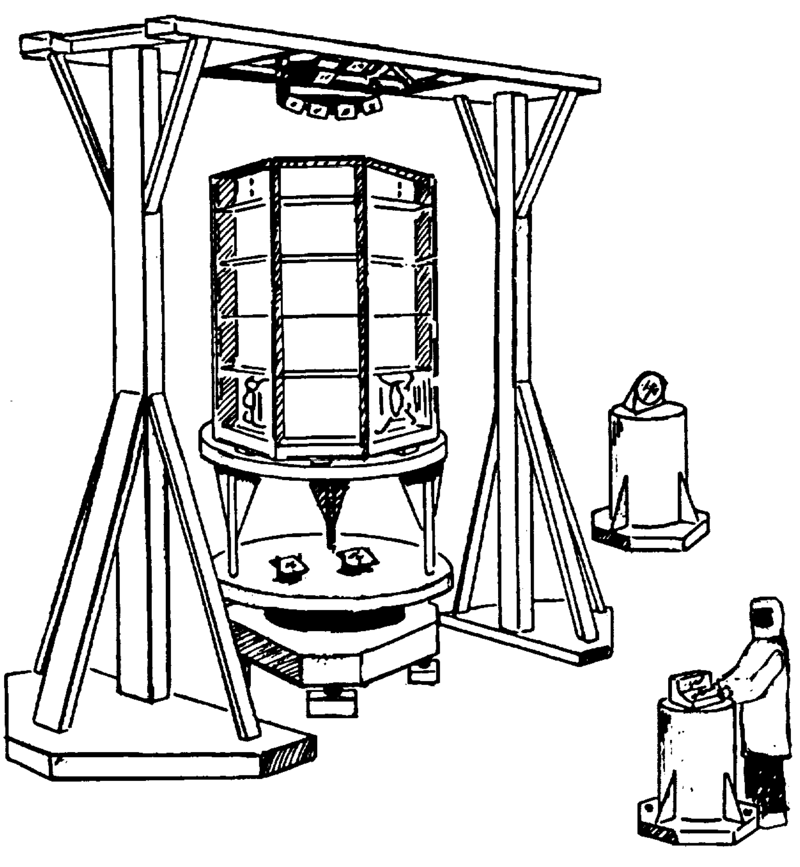
CONTACT – Richard Harner, Code 717 (Optical Test Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-8131.



Calibration Integration Alignment Facility



Spacecraft Optical Alignment Setup



Optical Alignment Facility

COMPUTER

MASSIVELY PARALLEL PROCESSOR FACILITY

DESCRIPTION

In response to NASA's need for very high speed computer design approaches for the 1980s, NASA's Office of Aeronautics and Space Technology developed the Massively Parallel Processor (MPP) supercomputer.

The MPP is a unique, single instruction stream, multiple data stream processor. NASA is evaluating the MPP for scientific applications. It is controlled and accessed through a VAX-11/780 host computer.

The MPP can execute 6.5 billion fixed-point additions per second. This provides a new standard of performance for solving image processing, weather modeling, synthetic aperture radar processing, and artificial intelligence problems, plus other problems structured with a high degree of parallelism.

Delivered by GOODYEAR AEROSPACE in 1983, the MPP is a testbed for research in information extraction, image analysis, simulation, and parallel algorithm development.

Features & Benefits

- 6.5 billion fixed-point additions per second with 100 nanosecond memory access time
- unique parallel software languages for easier programs
- extensive library of parallel computational algorithms for scientific applications

MODE OF OPERATION

The MPP gets its processing speed from an array of 16,384 processors operating in parallel. A staging memory containing up to 64 megabytes of storage and transferring data at rates up to 160 megabytes per second provides data communication with this array.

HARDWARE

The MPP consists of:

- array unit,
- array control unit,
- staging memory, and
- host computer

Array Unit

The array unit consists of a square array of 128 x 128 (= 16,384) processing elements (PE). Each PE is connected to its nearest neighbors: north, south, east and west. The programmer can connect opposite array edges or leave them open under program control. A separate I/O routing network allows data to enter and leave the array at a rate of up to 160 megabytes per second concurrent with array processing.

Array Control Unit

The array control unit executes the user program and provides the control to coordinate and perform I/O and array unit operations. Scalar operations are performed in the array control unit concurrently with operation in the array so that the full power of the array is always available. The array control has 3 control units, *i.e.*,

- main control unit,
- PE control unit, and
- I/O control unit.

All run concurrently, providing maximum processing efficiency.

Staging Memory

The staging memory is a large data buffer. It stores, permutes, and transfers data between external devices and the array. Using the staging memory, a programmer can accept data in virtually any format and permute it to the format best suiting his problem, with no program execution penalty.

Host Computer

The VAX host computer handles several ancillary tasks, *e.g.*, user interaction, I/O management, program development, user program compilation and assembly, I/O interface (between staging memory and peripherals), and execution of system tests and diagnostics.

Data can be transferred between the host computer and staging memory at 5 megabytes per second.

SOFTWARE

The MPP operating system provides a full set of capabilities to develop and debug application programs. These capabilities include a compiler for a parallel version of PASCAL for the main control unit and PE control unit. Subroutine libraries include parallel algorithms, I/O control software, and graphics capabilities.

A rich programming environment exists in the form of utility packages, specialized high performance subroutine libraries for computation and I/O, and the user capability to create customized MPP micro-code instructions.

A run-time operating system loads programs into the control unit memories and permits on-line execution and debugging of application programs. A staging memory manager program aids programming of the staging memory to permute input and output data.

APPLICATIONS

The MPP was developed for ultra high speed processing of satellite imagery. Shortly after delivery, the MPP performed common image classification tasks 1000 times faster than a VAX 11/780. The MPP also performed a simple global circulation simulation using a set of partial differential equations 4 times faster than a 2-pipe CYBER 205.

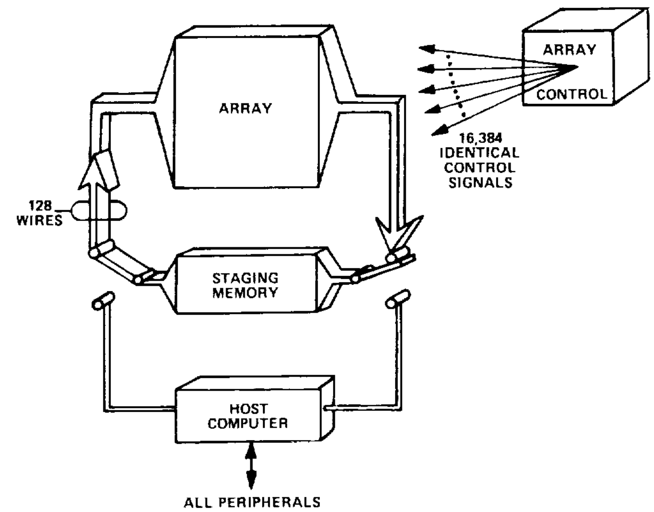
The MPP is a national resource in terms of computational power and unique parallel architecture. Because the architecture is unique, there is little published or unpublished material dealing with optimal programming techniques for such parallel processors.

To explore and document the capabilities of the MPP's architecture, NASA is soliciting proposals from all interested investigators within the United States to join an MPP Working Group.

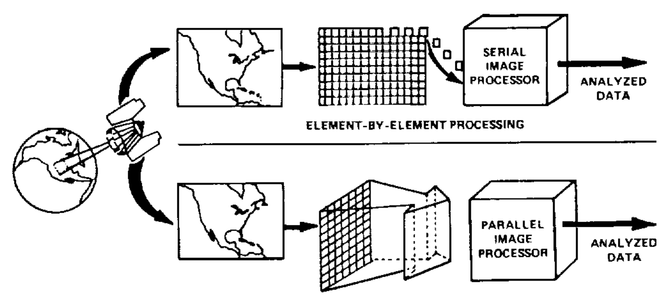
The current 40 Working Group members are conducting research into computational studies, *e.g.*, self-gravitating models for astrophysics and plasma physics, hydrodynamical modeling for oceans, hill slope models for ground water penetration circulation models, astrophysical image deblurring, animated graphics for time dependent data presentations, neural network models, and signal and image processing.

For example, a complete end-to-end Synthetic Aperture Radar (SAR) signal processing system was written for the MPP. The MPP converts raw SAR data into images in minutes.

CONTACT – James Fischer, Code 635 (Image Analysis Facility), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-3464.



Components of Massively Parallel Processor Facility



Parallel Processing

MATERIAL PROPERTIES
AND
ANALYSIS

Several of the services described in earlier sections can be obtained commercially. However, it may require considerable effort to locate these specialized services. On the other hand, most of the services described in the following section, Material Properties and Analysis, are readily available commercially. There are a number of companies that provide analytical services for individual tasks or under contract.

These companies and their services are listed in several publications. The Thomas Register is an excellent source of such information.

X-RAY DIFFRACTION & SCANNING AUGER MICROSCOPY/SPECTROSCOPY LAB

DESCRIPTION

The laboratory uses X-ray diffractometry and scanning auger electron microscopy to determine elements and chemical compounds in solid and/or their surfaces.

When used together these two techniques enable the experimenter to reduce the uncertainties involved in material identification.

X-ray Diffractometry is a qualitative and/or quantitative technique of analysis for solid and powdered organic or inorganic materials.

Material identification is possible due to the characteristic X-ray diffraction patterns obtained from the microstructure of solid crystalline compounds. Diffraction involves Bragg's Law:

$$\lambda n = 2d \sin \Theta$$

where λ is the wavelength of the X-ray beam, n is an integer, Θ is the angle of incidence, and d is the spacing between the crystal planes.

Scanning Auger Microscopy (SAM) is a versatile, microbeam analytical technique that characterizes elemental and chemical composition of surfaces and interfaces. An extremely surface-sensitive technique, all elements (except H and He) present in detectable amounts in the outer few atom layers of a material can be identified with SAM. When combined with ion sputter-etching, SAM can determine composition as a function of depth in a material.

X-RAY DIFFRACTION

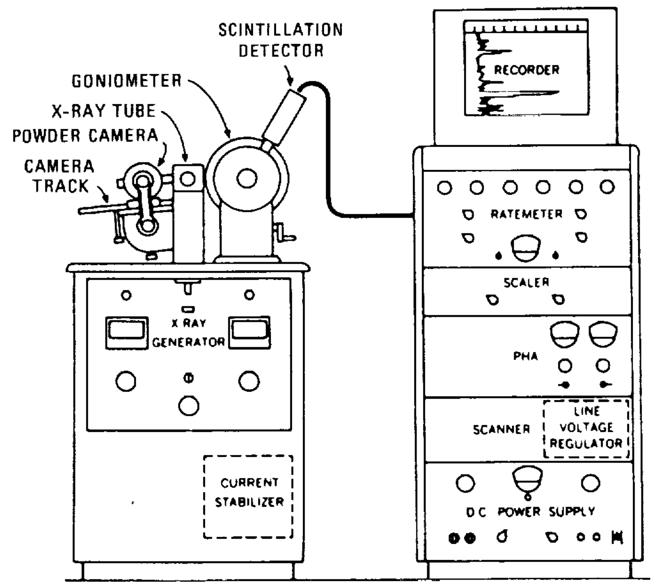
MODE OF OPERATION

The solid or powdered sample, is mounted in a flat metal holder (4 cm x 3 cm). Or, the powder may be put in a capillary in the middle of a camera surrounded by a strip of film.

The rotating sample is bombarded by a beam of X-rays produced in a target tube by a high voltage generator.

The diffracted X-rays are detected by a scintillation counter detector and recorded on a strip chart. Or, if the sample is in the camera, the diffracted rays are exposed as lines on the film.

From the values of 2 Θ at which diffraction occurs, d spacings are calculated using Bragg's Law, and search manuals (JCPDS) are used to match a characteristic set of d spacings (or pattern) to a specific chemical compound. These files contain patterns of 46,000 + compounds.



X-Ray Diffraction; Typical Instrument Setup

USES

Qualitative and quantitative analyses of organic and inorganic materials such as steels and plastics for certification, quality control, research and development. Also, stress measurements on materials can be made, *i.e.*, there is a change in the particular d spacings of a crystalline material in areas where residual stress is present, and measurement of this distortion is the basis for residual stress determinations.

PARAMETERS

Usable angular range . . . . 5–150 deg

Precision of measurements . . . . 0.0005 deg

Sample characteristics . . . . 3 gms powdered material (1–50 μm particle size as homogeneous as possible for sample holder in diffractometer and 10 mg when DEBYE SCHERRER camera is used)

X-RAY DIFFRACTION & SCANNING AUGER MICROSCOPY/SPECTROSCOPY LAB

Limit of detection .... (example) in a mixture of anatase and rutile, the former can be determined at 100 ppm with an error of 4%. Qualitative analysis allows smaller samples.

INTEGRAL INSTRUMENTATION

Scintillation counter, X-ray goniometer, high voltage generator, high voltage stabilizer, data control/ strip chart recorder.

NOTE: A fully-automated and computerized X-ray diffraction system with the capability of testing small samples without a camera is expected to be operational late 1986.

SCANNING AUGER MICROSCOPE

MODE OF OPERATION

A specimen in an ultra high vacuum is bombarded with a focused electron beam probe. Incident electrons collide with inner shell electrons, creating an electron vacancy. When an ionized atom relaxes to an equilibrium state, an X-ray photon or a second, so-called "Auger electron" is emitted.

Auger electrons created in the first few atomic layers can escape from the solid with characteristic kinetic energies indicative of the host species.

The use of an energy analyzer to determine these energies yields a spectrum with readily identifiable Auger peaks.

PARAMETERS

Operating modes .... Electron micrograph; Auger image, Auger line analysis, Auger point analysis, thin film analysis

Probe electron beam
- Diameter .... Less than 5 μm at 10 keV, 0.1A
  Less than 15 μm at 5 keV, 3A
- Current .... Variable to greater than 5 A
- Energy .... 1 keV to 10 keV

Scanning System
- Operating modes .... TV (secondary electron Micrograph only), repetitive, single, line, spot
- Scanned area .... 1 cm x 1 cm max (micrograph) 200 μm x 200 μm max (Auger Image)
- Auger image frame time .... 1 min
- Useful magnification .... 20X - 500X

Scanning Display System
- Visual .... TV; storage CRT
- Record .... CRT display monitor

Thin Film Analyzer
- Sputter-Etch rate ..... 100Å/min. (typical)
- Readout .... Point plot of peak-to-peak Auger amplitude or analog printout of peaks with six channel multiplexing

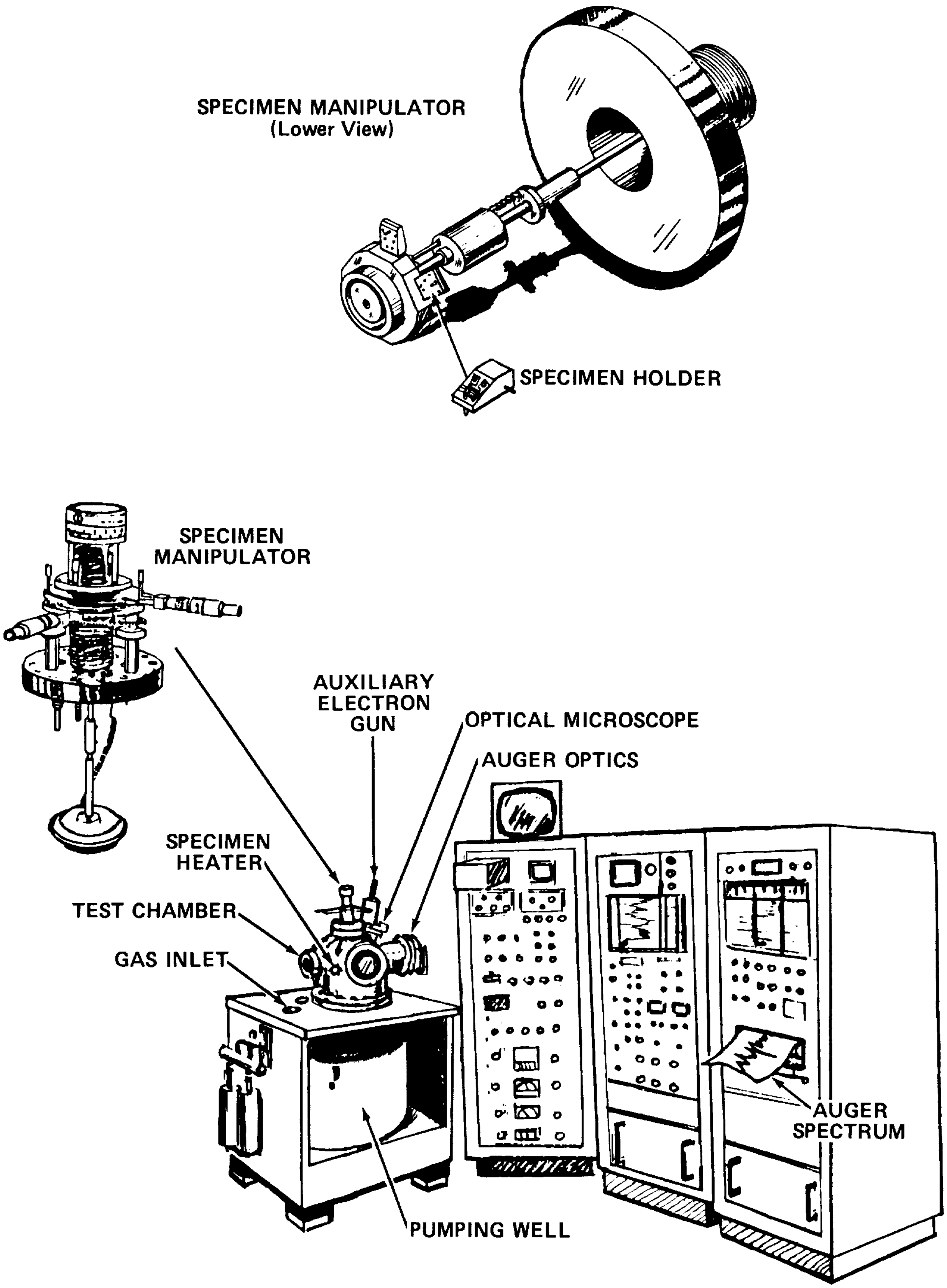
Specimen Stage
- Degrees of freedom .... 3 translations rotation; 2 tilts
- Number of specimens 6
- Test Chamber ..... 30 cm dia. x 30 cm high

REFERENCES

R. Jenkins and J. L. deVries, *An Introduction to X-ray Powder Diffractometry,* N.V. Philips Gloelampenfabrieken (Eindhoven, Holland).

JCPDS Publications, Joint Committee for Powder Diffraction Standards, (Swarthmore, PA).

CONTACT – Jeanette Stack and James Wall, Code 313 (Materials Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-5827.



Scanning Auger Microscope

PARTS ANALYSIS LABORATORY

DESCRIPTION

The Parts Analysis Laboratory performs failure analysis and construction analysis (destructive physical analysis) on electric, electromechanical, and mechanical components.

A **failure analysis** determines the physical mechanisms of failure(s) so they can be classified according to the cause, *e.g.*, manufacturing defect, overstress, misapplication, inadequate specification, improper testing, and misclassification of the failure.

A **construction analysis** determines if the component has characteristics and construction features that make it suitable for space flight use. To accomplish these objectives it is necessary to perform extensive electrical, mechanical, environmental and analytical testing, and document these results with detailed reports and photographs.

MODE OF OPERATION

Each failure analysis is unique because the starting point is determined by the background and device type. The results of each test performed determine the type and extent of any subsequent test and analysis. The objective of any failure analysis is to confirm the reported failure and determine the cause of the failure so corrective action can be taken.

A construction analysis, in contrast, is performed in accordance with GSFC specification S-311-70. Each type of component is tested in a similar manner to the requirements of a specific MIL specification.

HARDWARE

- Two Scanning Electron Microscopes capable of 100 Å resolution, and having dynamic focusing, electron beam induced current and voltage contrast capability.
- Energy Dispersive Spectrometer to identify all but the lightest elements (sodium upward), with a resolution of 180 electron volts.
- Dynamic X-ray (up to 250 KV), 2 high power optical microscopes, a high power infrared microscope, and several low power microscopes.
- He leak detector, gross leak detector, lead pull tester, die shear tester, PIND tester, laser zapper, and 2 probe stations.
- Electrical test equipment including logic analyzers, oscilloscopes (high speed, storage, programmable), curve tracers, bridges, fiber optic test equipment, ESD simulators, signal generators, recorders, assorted meters, computer terminal, and a personal computer.

INTEGRAL INSTRUMENTATION

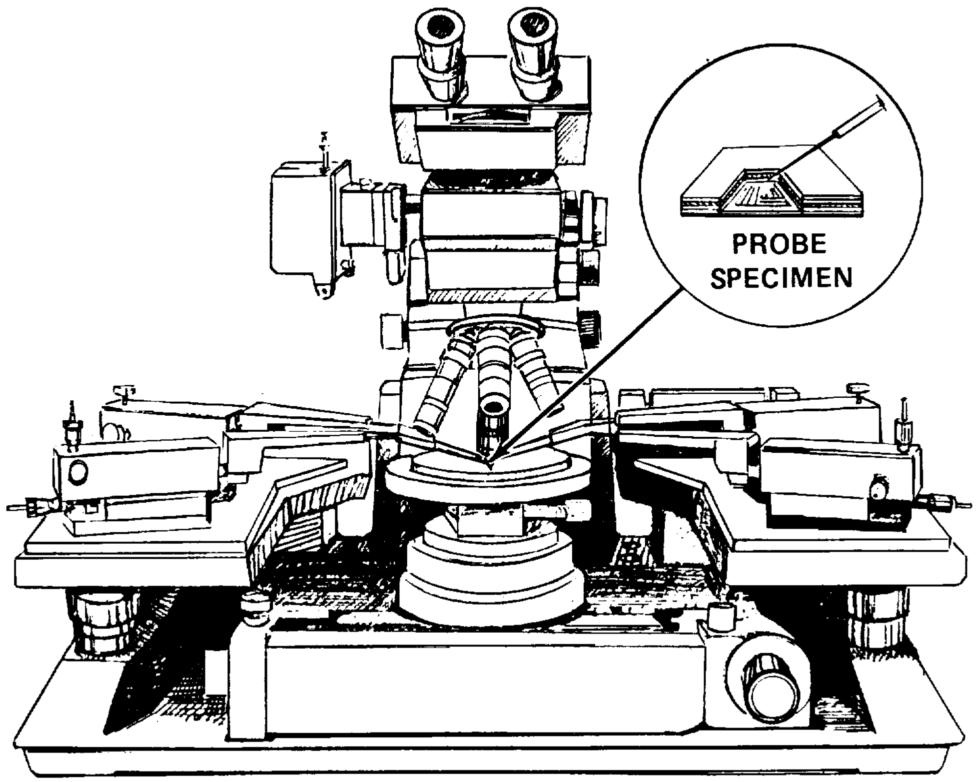
Most equipment discussed in the **HARDWARE** section is used for data acquisition. The laboratory uses a computer and makes use of automated test equipment at the Test and Inspection facility in Lanham, MD.

REFERENCES

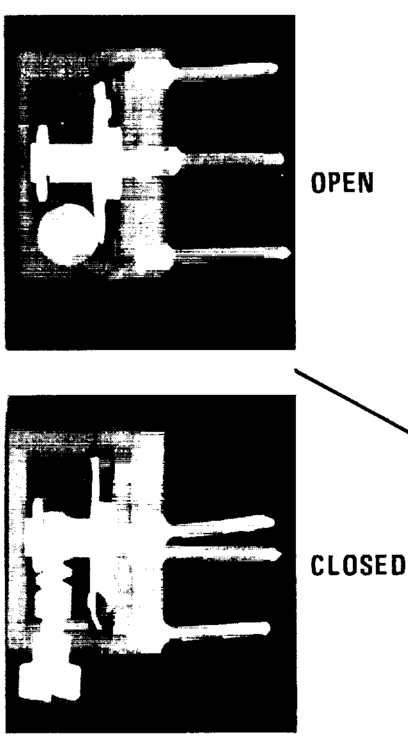
Ed Doyle, Jr., Rome Air Development Center, Air Force Systems Command, and Bill Morris, General Electric Company, *Microelectronics Failure Analysis Techniques: A Procedural Guide,* circa 1983.

Robert J. Anstead, *Construction Analysis of Electronic Parts, Specification for,* GSFC Specification Document S-311-70 (January 5, 1976).

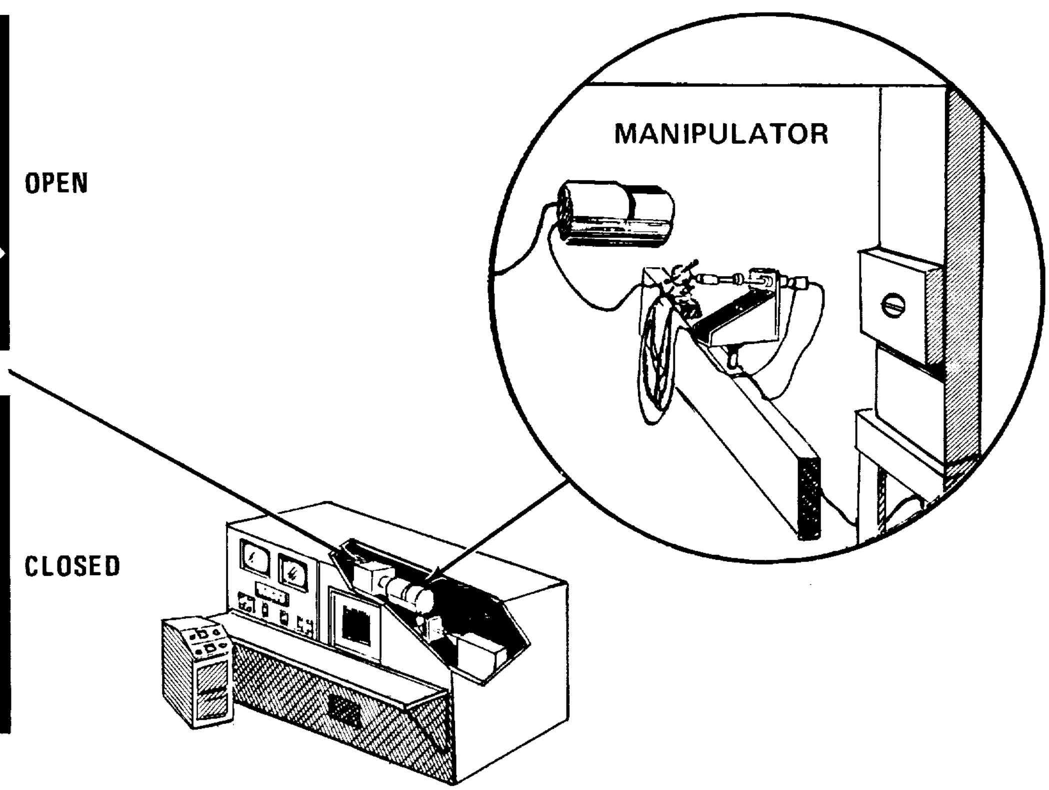
CONTACT – Perry R. Mason, Code 311 (Parts Branch) NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-5384.



High Powered Microscope with Probing Station



X-RAY PHOTO
OF SWITCHES



Dynamic X-Ray Facility

RADIATION TEST FACILITY

DESCRIPTION

The Radiation Test Facility exposes spacecraft electronic components to space environment radiation simulations.

Radiation rates vary from low rates (a few events/second) to damage level intensity (5K rads/minute max.)

There are 5 sources of radiation:

- 3.5K curies Co60 gamma ray source,
- 7K curies Co60 gamma ray source,
- 2 MEV Van de Graaff (Damage Study) Accelerator,
- 2 MEV Van de Graaff (Instrument Calibration) Accelerator, and
- 150 KEV (Instrument Calibration) Accelerator.

There are 2 vacuum chambers for use with the instrument calibration accelerators.

MODE OF OPERATION

Tests are conducted by placing items to be irradiated in the chamber and exposing them for a specified time.

For the 7K curies gamma radiation source, the irradiation test area is a large room. Typically, tests are conducted by placing items to be irradiated on a table, adjusting the distance to the source to obtain the desired bombardment rate, and setting the timing for the total dose. Electrical connections and cables are made through a trench into the control room area.

For the 2 MEV Van de Graaff Accelerator, access to the beam is by a multiported system. Items may be irradiated by electrons in air through a 2" x 12" window port. Proton or ion irradiation can be done inside the vacuum chambers. Electrical feedthroughs are available.

For the two instrument calibration accelerators preparation includes defining the mechanical interface with chamber and turntable, the electrical interface, type and number of feedthroughs, and monitoring requirements for each experiment.

Before bombardment begins, mount detector system in chamber, check alignment of detector with beam and monitor system. Test experiment electronically, including (a) feedthroughs and cable signals, and (b) check for interference between peripheral equipment and detector system, monitor system, computer and accelerator.

PARAMETERS

	3.5K curies Gamma Ray Source	7K curies Gamma Ray Source
Location	in lead pig	opens into lead shielded room
Specimen size	6" dia x 7"H	5' x 5' x 5'

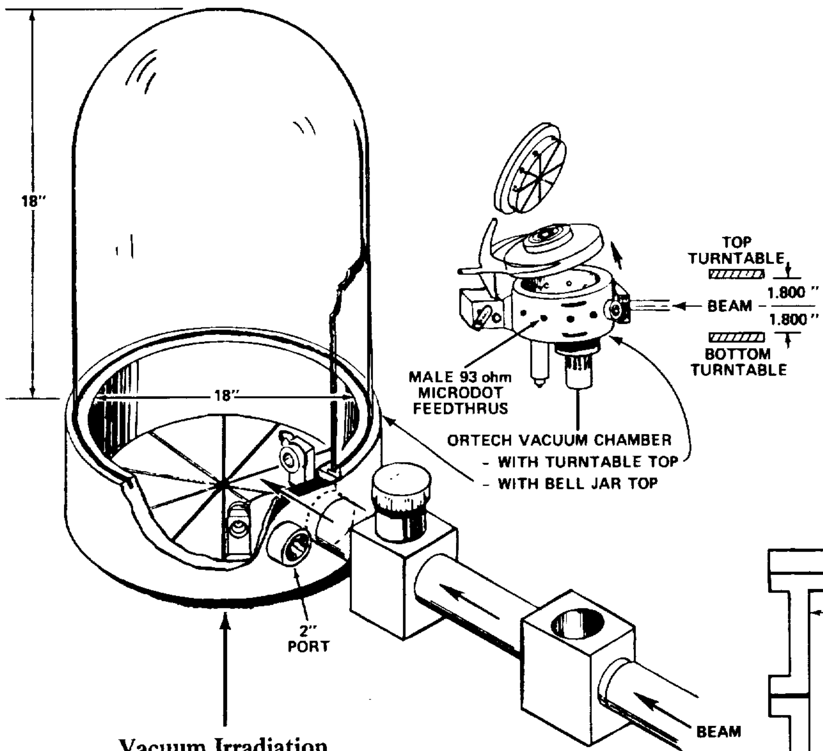
. . . Accelerators . . .

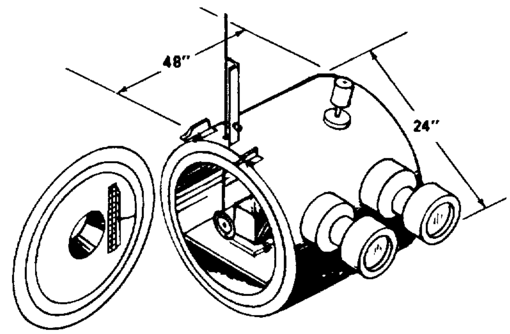
	2 MEV Van de Graaff	2 MEV Van de Graaff	150 KEV
	Electron beam energy range		
low	0.5 MEV	0.1 MEV	1 KEV
high	1.8 MEV	1.8 MEV	150 KEV
	Electron beam intensity range (particles/cm²/sec)		
low	3×10^{12}	10^{2}	10^{2}
high	6×10^{14}	10^{7}	10^{7}
	Positive ion energy range		
low	100 KEV	35 KEV	1 KEV
high	1.9 MEV	1.9 MEV	150 KEV
	Positive ion intensity range (particles/cm²/sec)		
low	6×10^{8}	10^{2}	10^{2}
high	6×10^{14}	10^{7}	10^{5}

DATA ACQUISITION CAPABILITIES

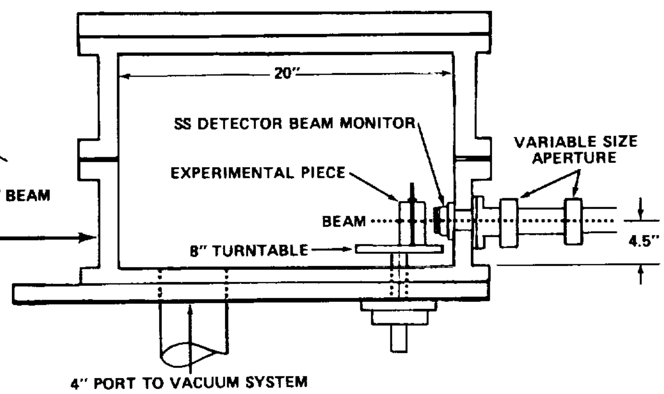
ND 2200 Pulse Height Analyzer, with paper tape printout or magnetic tape, **HP 5201L scalar timer analyzer**, **KEITHLEY 620 electrometer**, and **TI 990 microprocessor**, with printer and disk, which analyzes pulse height, controls monitor and turntable, processes data into table form, prints graphs.

CONTACT – Steven Brown, Code 311 (Parts Support Services Section), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-2905.

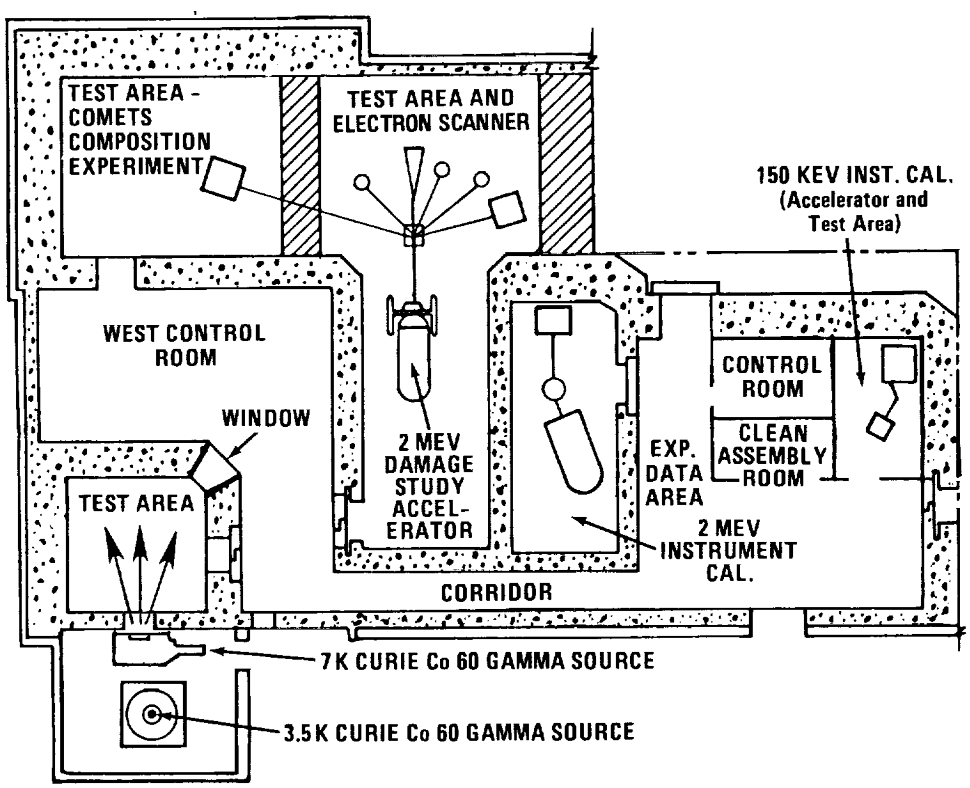




Instrument Test Chamber



Vacuum Irradiation Test Chambers



Radiation Test Facility

AINSWORTH VACUUM BALANCE FACILITY

DESCRIPTION

The AINSWORTH Recording Vacuum Balance Facility measures weight loss of organic specimens vs. time with temperature control.

MODE OF OPERATION

- Tare the sample manually. Pull vacuum and begin test.
- As a sample loses weight, a 10 mg weight is automatically removed from the balance pan. If the weight changes exceed the recording range, a motor and mechanical cams and levers add or subtract weights and rescale the system.
- Monitor weight loss until equilibrium is achieved.
- Run complete.
- Apply heat (in increments as small as 5°C). Repeat test as above.

PHYSICAL CHARACTERISTICS

Maximum Specimen Size

For Heating Chamber . . . . 2" dia x 3"L

Vacuum Chamber Size

Inside diamater . . . . 3" dia x 20"L

Furnace

External Size . . . . 9" dia x 12"H

Temperature Range . . . . . ambient to 125°C

PARAMETERS

Max. test temperature . . . . 125°C

Typical pump down time to 10^{-6} torr . . . . 30 minutes

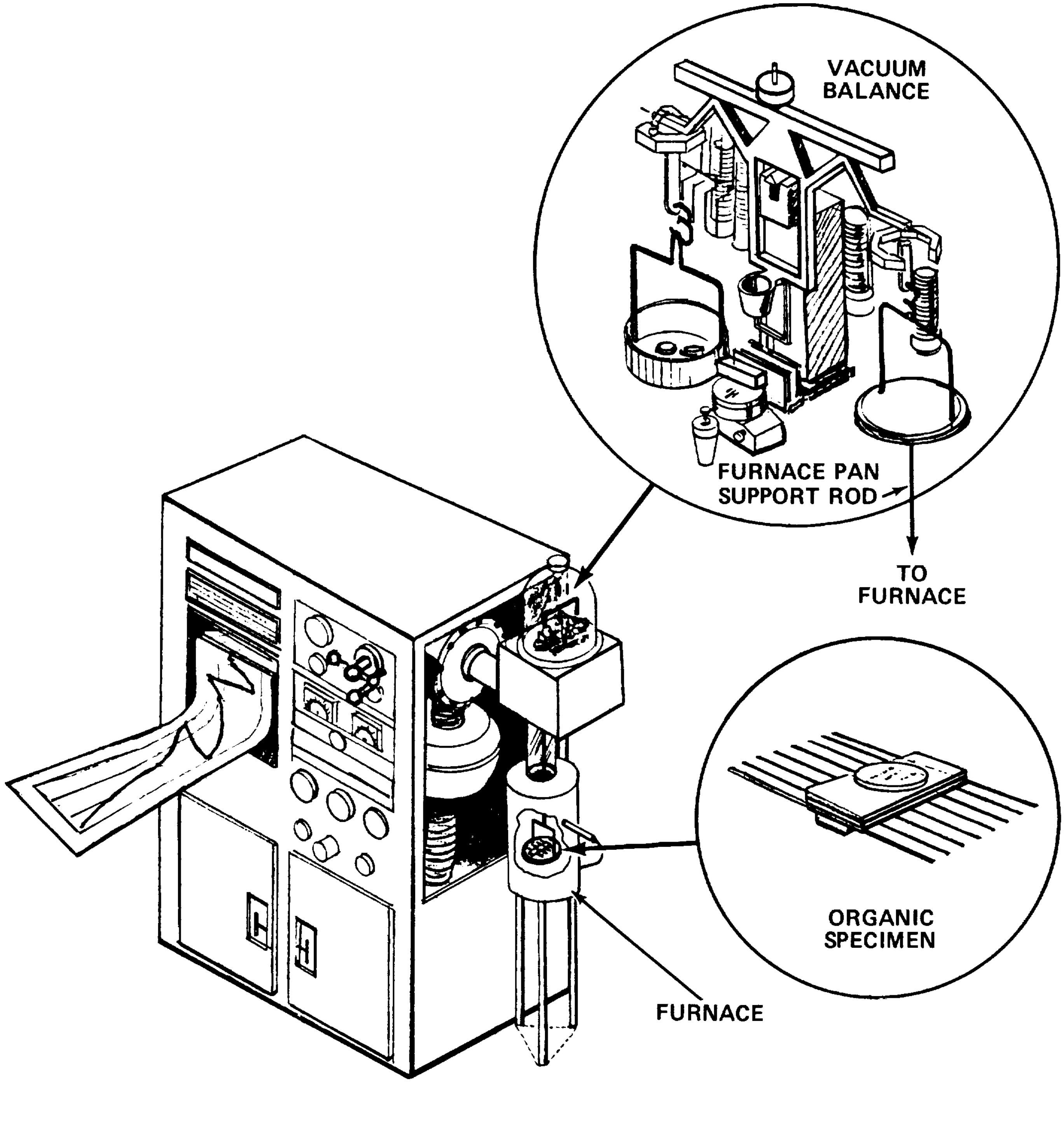
Ultimate pressure . . . . 10^{-6} torr

	. . . Dual Sensitivity . . .	
	Analytical	Semi-Micro
Capacity	200 g	100 g
Sensitivity 1 chart division	1 mg	0.1 mg
Readability by estimation	0.1 mg	0.01 mg
Reproducibility	S = ±0.1 mg	S = ±0.03 mg
Accuracy		
max. beam arm length error	10 ppm	10 ppm
built-in weights	NBS class S	NBS class S
max. variation of sensitivity through load range	0.5%	0.5%
Span on chart	100 mg	10 mg
Range of automatic weights	400 mg	400 mg
Chart speeds (gears supplied)		
with 1-pen recorder	1½, 3, 6, 12, 24 in/hr	1½, 3, 6 12, 24 in/hı
with 2-pen recorder	5, 15, 30, 60 in/hr	5, 15, 30, 60 in/hr

INTEGRAL INSTRUMENTATION

Two variable speed plotter-recorder pens record (1) temperature and (2) weight loss. Pens typically write 1"/hour.

CONTACT – Ronald Hunkeler, Code 313 (Materials Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-2879.



Ainsworth Vacuum Balance Facility

METALLOGRAPHY LABORATORY

DESCRIPTION

The metallography laboratory performs:

- **Failure analysis** locating the cause for failure in material or part,
- **General metallurgy** *i.e.*, characterizing the microstructure, hardness, and temper of metal (*e.g.* annealed, cold worked),
- **Printed circuit board compliance** to metallographic evaluation described in MIL-P-55110D,
- **Image analysis system** gives statistical computations for clean room witness mirrors, phases in a microstructure or any other image that may be projected onto a magnetic pad using a microscope, and
- **Non-destructive testing** including photography, radiography to detect subsurface flaws, and dye penetrant inspection to locate flaws open to the surface.

MODE OF OPERATION

Depending on the job requirements, the work could include visual inspection, photography, sample sectioning, metallographic sample preparation (mount, grind and polish), radiography, dye penetrant, hardness, data acquisition for image analysis, or solder float testing for circuit board evaluation.

INTEGRAL INSTRUMENTATION

Radiography produces an X-ray film record. Image analysis uses CRT display and OKIDATA printer. All other tests suiting themselves to photography may be photographed on instant film to document results and observations. No negatives or enlargements of photos can be made.

CONTACT – Diane Kolos, Code 313 (Materials Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-3880.

PARAMETERS

Procedure	Magnification	Maximum Object Size
Photography		
General	1-14x	48" L x 48" W x 36" dia
General	7-40x	1 ft^2 (approx.)
Metallographic sample	5-1000x	1.5" dia
Radiography		
200 kv unit	1x	4' x 4' (thickness depends on material density)
Sample Sectioning		
High speed cut off	N/A	23" L x 3" W x 3" dia
Low speed cut off	N/A	12" L x 1.5" W x 1.5" dia
Variable speed cut off	N/A	12" L x 1.5" W x 1.5" dia
Dye Penetrant Inspection	8-50x	4" L x 4" W x 4" dia
Image Analysis		Projected Image
with microscope	8-50x	11" x 11"
with metallograph	50-1000x	11" x 11"

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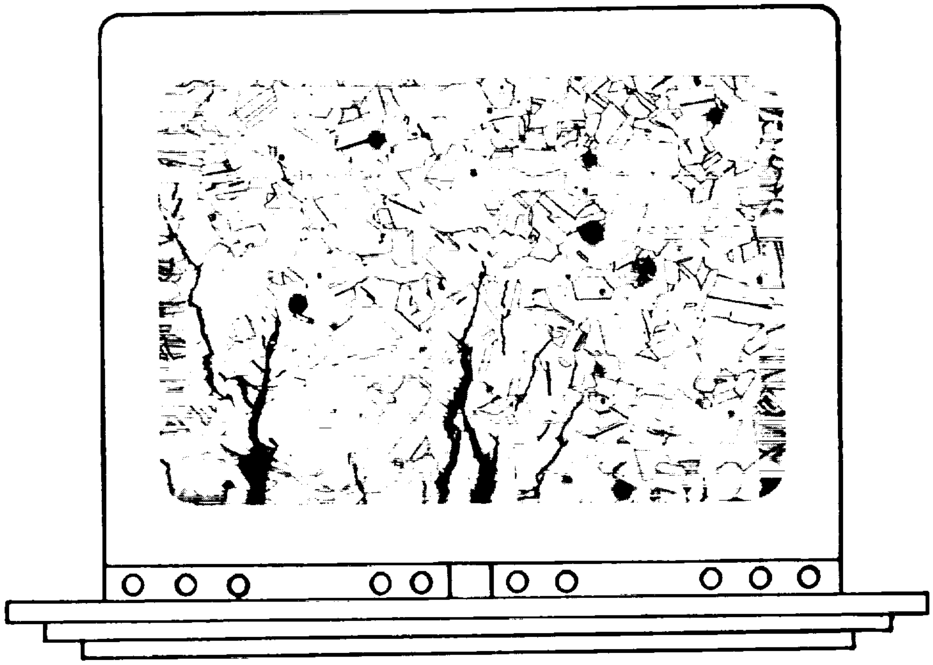
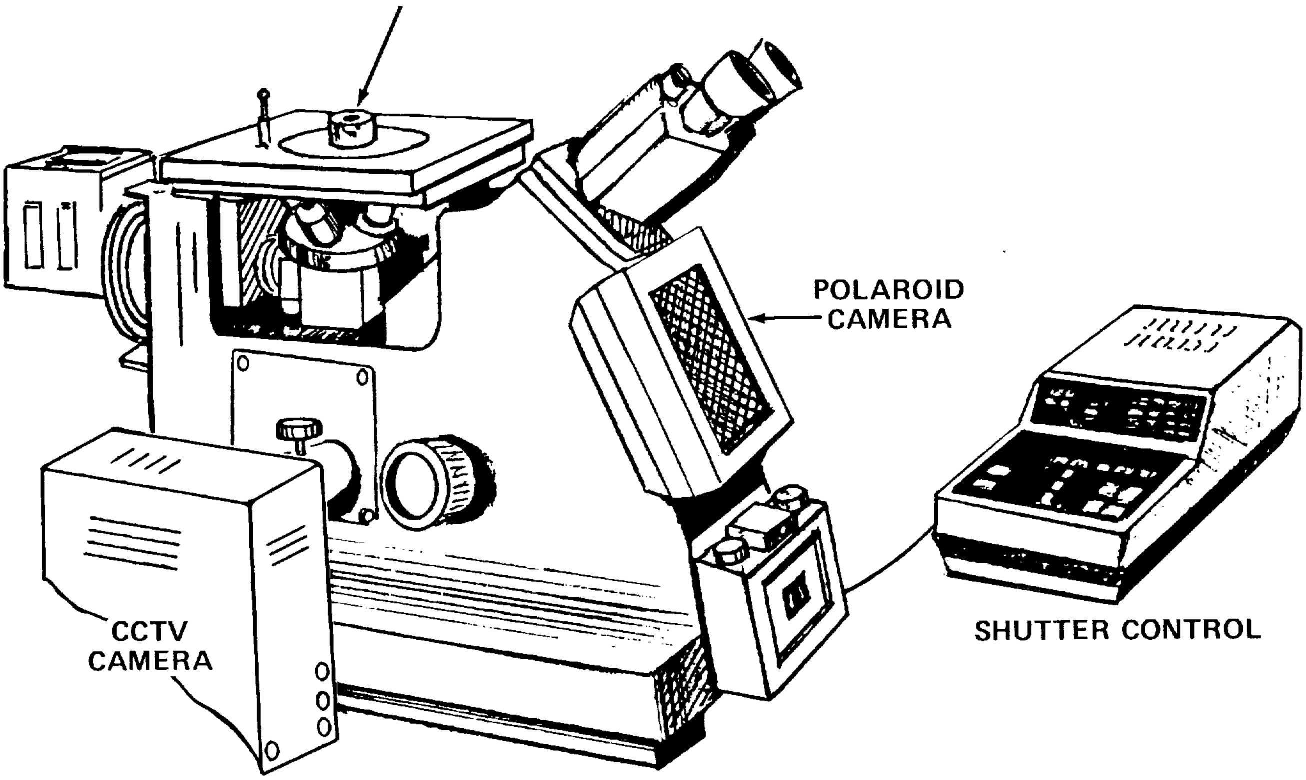


Video Display Terminal Showing Cross Section of
Stress Corrosion Cracking of Stainless Steel



Metallograph with Cross Section

SCANNING ELECTRON MICROSCOPE LABORATORY

DESCRIPTION

The Scanning Electron Microscope Laboratory performs characterizations of solid materials and surfaces on a micrometer scale. Information obtained includes **topographic information** contained in images obtained at high magnification and resolution, using a scanning electron microscope, and **elemental analyses** of both a qualitative and quantitative nature, using an energy dispersive X-ray spectrometer and a wavelength dispersive X-ray spectrometer.

MODE OF OPERATION

The laboratory assists in failure analyses by using fractography to reveal failure modes, certifies the composition of metallic materials, performs elemental analysis of non-organic contamination, and examines composition of individual parts components and integrity of parts packaging.

INTEGRAL INSTRUMENTATION

PHILIPS Model PSEM 500 Scanning Electron Microscope (SEM).

EDAX International Inc. Model PV9100/60 Energy Dispersive X-ray Spectrometer (EDS).

MICROSPEC Model WDX-2A Wavelength Dispersive X-ray Spectrometer (WDS).

PARAMETERS

SEM

magnification . . . . 10X - 100,000X
resolution . . . . approx. 500 Å
accelerating voltage . . . . 1.5 to 50 KV
detectors:

SED - secondary electron detector
BSD - backscattered electron detector
SCD - specimen current detector

working distance . . . . 9.5 or 32.5 mm
beam current . . . . 10^{-12} to 10^{-16} amp
specimen size . . . . 45 mm dia x 25 mm H

EDS

analysis of elements down to . . . . Sodium
detection limit . . . . . . 1000 ppm (most elements)
resolution . . . . 150 ev to 160 ev (FWHM) for MnKα
detector . . . . silicon drifted with lithium
Software provides:

- semi-quantitative results in weight or atomic percents
- quantitative results, if referenced standards available
- X-ray dot maps and line scans

WDS

analysis of elements down to . . . . Boron
detection limit . . . . 100 ppm (most elements)
resolution . . . . 3 - 25 ev (FWHM) for most elements
optics . . . . linear, fully focusing
analyzing crystals . . . . 4 (standard)
detectors . . . . 2 gas proportional counters, mounted in tandem:

- Front detector: Argon flow proportioned counter (FPC)
- Rear detector: Xenon scaled proportioned counter (SPC)

DATA ACQUISITION CAPABILITIES

Energy Dispersive Spectrometer

- Main cabinet houses Analog-to-Digital-Converter (ADC), Multichannel Analyzer (MCA), 2 floppy disk drives, and LSI-11 Computer.
- Data is displayed on CRT; stored on floppy disk. Hard copies of data are obtained using either XY plotter or printer.

Wavelength Dispersive Spectrometer

- A microprocessor-based integrated digital control and readout electronics system provides programmable operation of system.
- System output is displayed on CRT; input to system is via keyboard.
- Strip chart recorder provides hard copy of spectral scans.
- Automatable by external control via the energy dispersive spectrometer system which allows storage of data on floppy disk.

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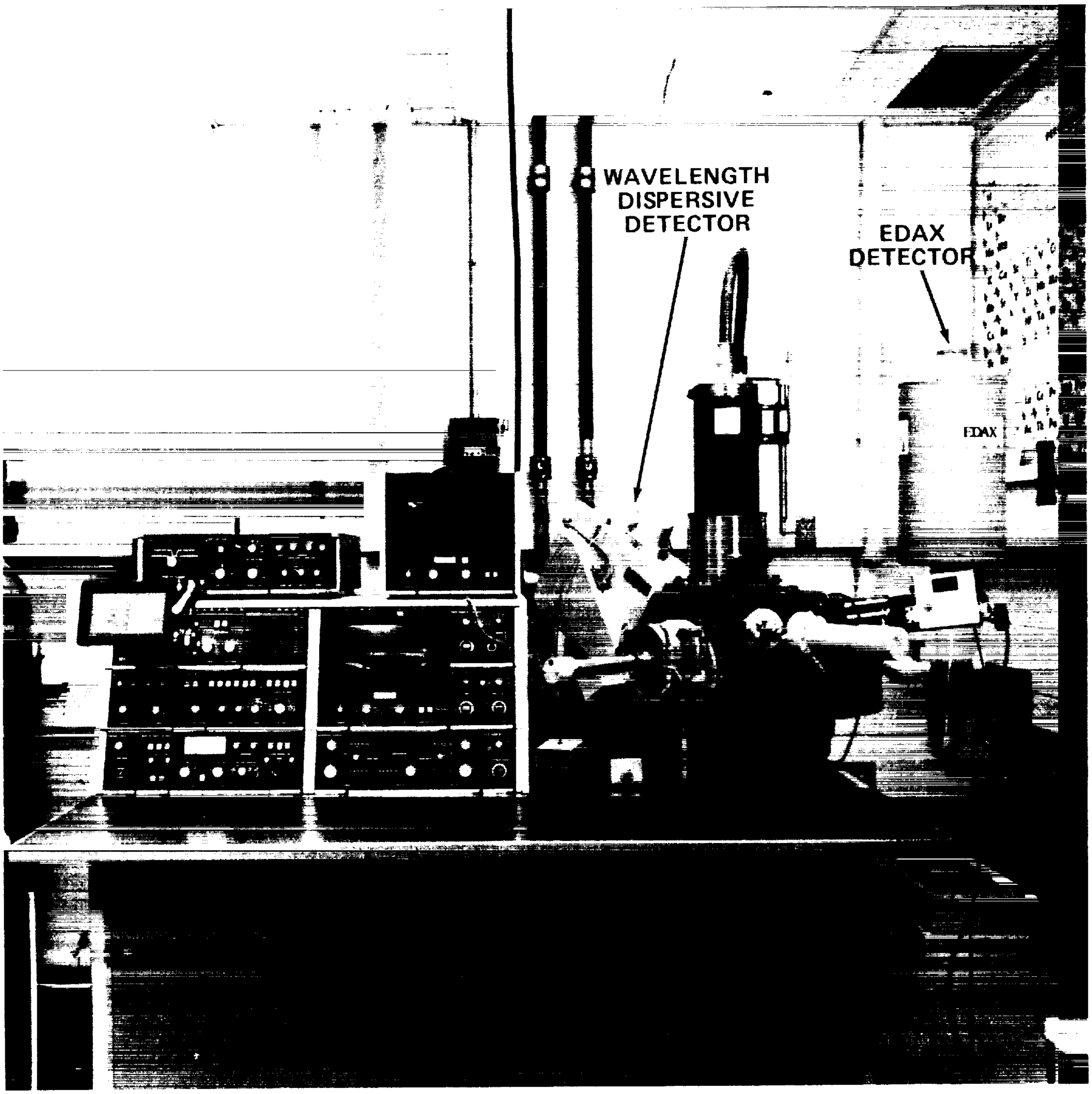
REFERENCES

Goldstein, Yakowitz, et al., Practical Scanning Electron Microscopy, Plenum Press (New York, 1975).

Postek, Howard, et al., Scanning Electron Microscopy: A Student's Handbook, Ladd Research Laboratories (1980).

CONTACT – Bradford Parker, Code 313 (Materials Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-8548.



Scanning Electron Microscope

ORGANIC ANALYSIS LABORATORY

DESCRIPTION

The Organic Analysis Laboratory solves problems relating to organic contamination of spacecraft and flight hardware where such contamination might adversely affect instrument performance or mission objectives. The lab also provides polymer evaluation, including thermal decomposition, outgassing species, and thermal properties analysis.

Organic analyses using infrared spectroscopy and gas chromatography/mass spectrometry are performed on a Perkin-Elmer 283B Infrared Spectrophotometer linked to a Perkin-Elmer 3500 data station, and a Varian 3300 gas chromatograph interfaced with a Nermag R10-10C mass spectrometer. The latter is connected to a Finnigan 2400 data system which is used to process advanced mass spectral programs.

MODE OF OPERATION

Services include:

- chemical identification of outgassing species from polymeric materials used in hardware fabrication,
- monitoring thermal vacuum chamber contaminant levels and molecular species,
- sampling suspected contaminated surfaces on hardware and certification of cleanliness level, and
- consulting with experimenters and test personnel to determine contaminant sources, cleanup procedures and appropriate further testing.

Lab personnel possess extensive expertise in micro-sampling and chemical analysis, including selection of appropriate techniques, verification of solvent purity, selection of wipe sampling materials, and handling procedures for meaningful analysis.

PARAMETERS

Infrared Analysis

Frequency range . . . . 200 to 4000 cm^{-1}

Sample size . . . . A sample of 0.1 mg is usually required.

GC/MS Analysis

Mass range . . . . 4 to 2000 AMU

Sample size . . . . A μL concentrated sample is usually required.

Sensitivity . . . . 10^{-10} g per component

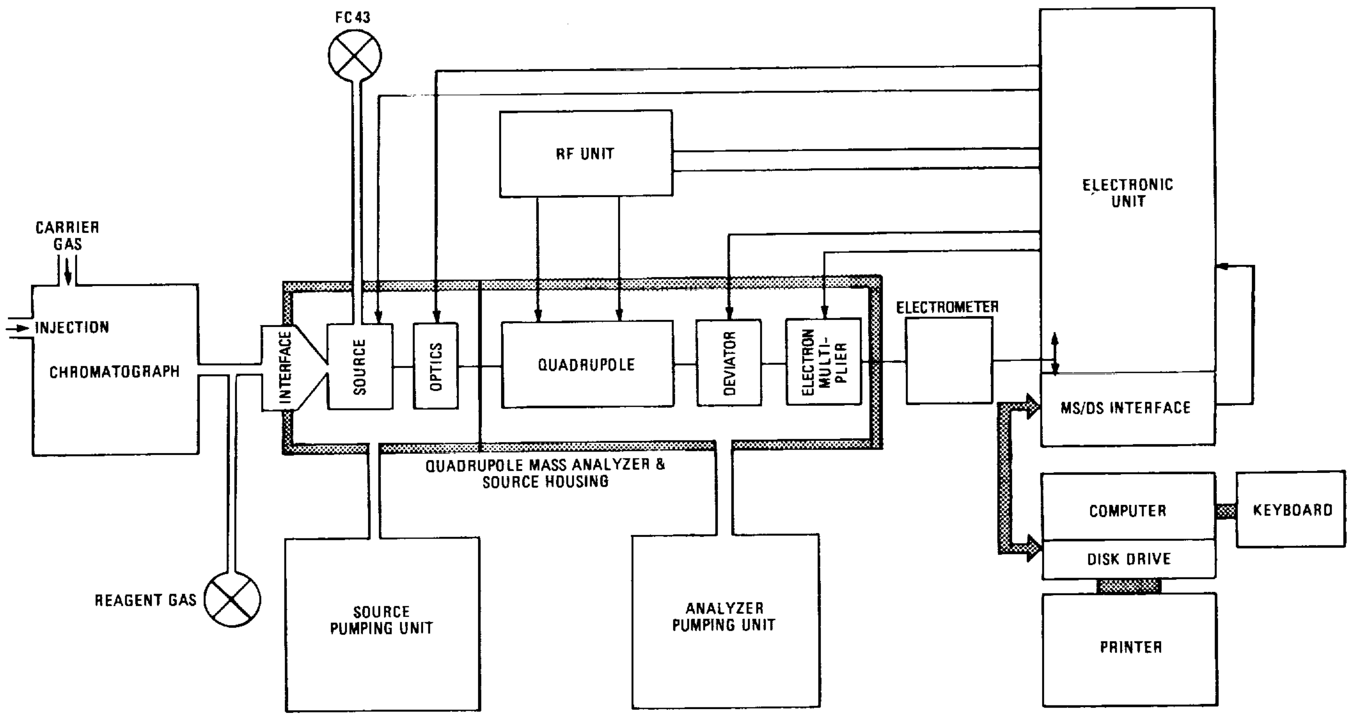
Collection of samples should be performed by a properly trained individual.

INTEGRAL INSTRUMENTATION

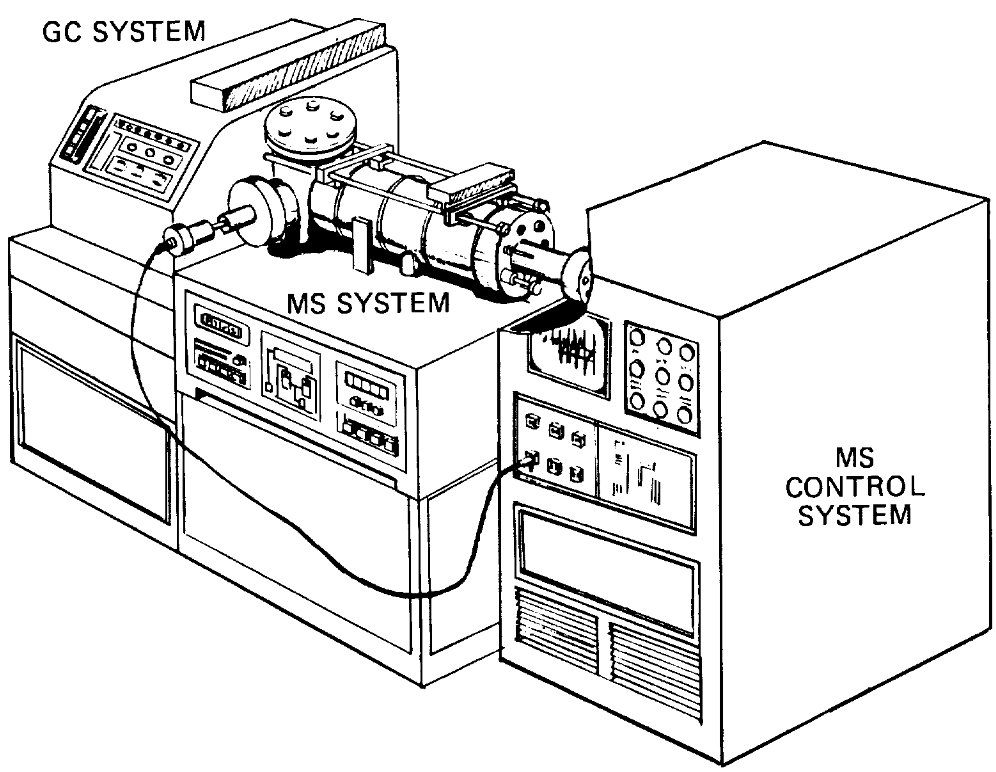
- Research grade dispersion–type infrared spectrophotometer.
- Quadrupole mass spectrometer featuring:
  - thermal probe inlet,
  - gas inlet,
  - gas chromatograph inlet, and
  - desorption probe inlet.

Data is collected on a high-speed 16-megabyte disk system and processed by advanced mass spectral programs, including a 35,000 entry library of known spectra.

CONTACT – Joe Colony, Code 313 (Materials Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-5288.



Gas Chromatograph/Mass Spectrometer Block Diagram



Gas Chromatograph/Mass Spectrometer System

OUTGASSING TEST FACILITY

DESCRIPTION

The Outgassing Test Facility provides accelerated testing in a vacuum environment of polymeric materials being considered for use in spacecraft and associated components. The primary data base generated compares 3 areas of possible contamination during mission lifetime:

- % Total Mass Loss (TML) of a material,
- % Collected Volatile Condensable Material (CVCM), or surface contamination, and
- % of Water Vapor Regained (WVR), or water absorption/adsorption by a material.

MODE OF OPERATION

This test procedure allows uniformity of conditions and testing of all processed materials. This allows comparisons for subsequent choice in materials used in spacecraft construction.

- Weigh the sample holders, sample(s), and collector plates before starting the test process.
- In a vacuum environment, heat the sample(s) to 125°C for 24 hours.
- Collector plates (maintained at 25°C) collect the condensable contaminating substances.
- At the end of the test, weigh the sample holders, sample(s), and collector plates.
- Calculate TML, CVCM, WVR.
- Insert these values into the data base.

PARAMETERS

Sample/specimen wt.	approx. 250 mg
Specimen temperature	125°C
Collector plate temperature	25°C
Test duration	24 hours
Pressure	5 x 10^{-5} Torr (or less)

PHYSICAL CHARACTERISTICS

Vacuum is produced by oil diffusion pump. Relative humidity chamber produces constant temperature and humidity for conditioning sample materials. Microbalance is capable of microgram measurements.

INTEGRAL INSTRUMENTATION

Chart recorder to monitor temperatures. Temperature controllers and constant temperature circulating bath. Vacuum system and controls.

REFERENCES

William Campbell, Richard Marriott, and John Park, *Outgassing Data for Selecting Spacecraft Materials,* NASA Reference Publication 1124, June 1984.

Annual Book of ASTM Standards, "Standard Test Method for TOTAL MASS LOSS AND COLLECTED VOLATILE CONDENSABLE MATERIALS FROM OUTGASSING IN A VACUUM ENVIRONMENT," American Society for Testing Materials (Philadelphia: 1984), ASTM E-595-84.

CONTACT – William Campbell, Code 313 (Materials Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-6508.

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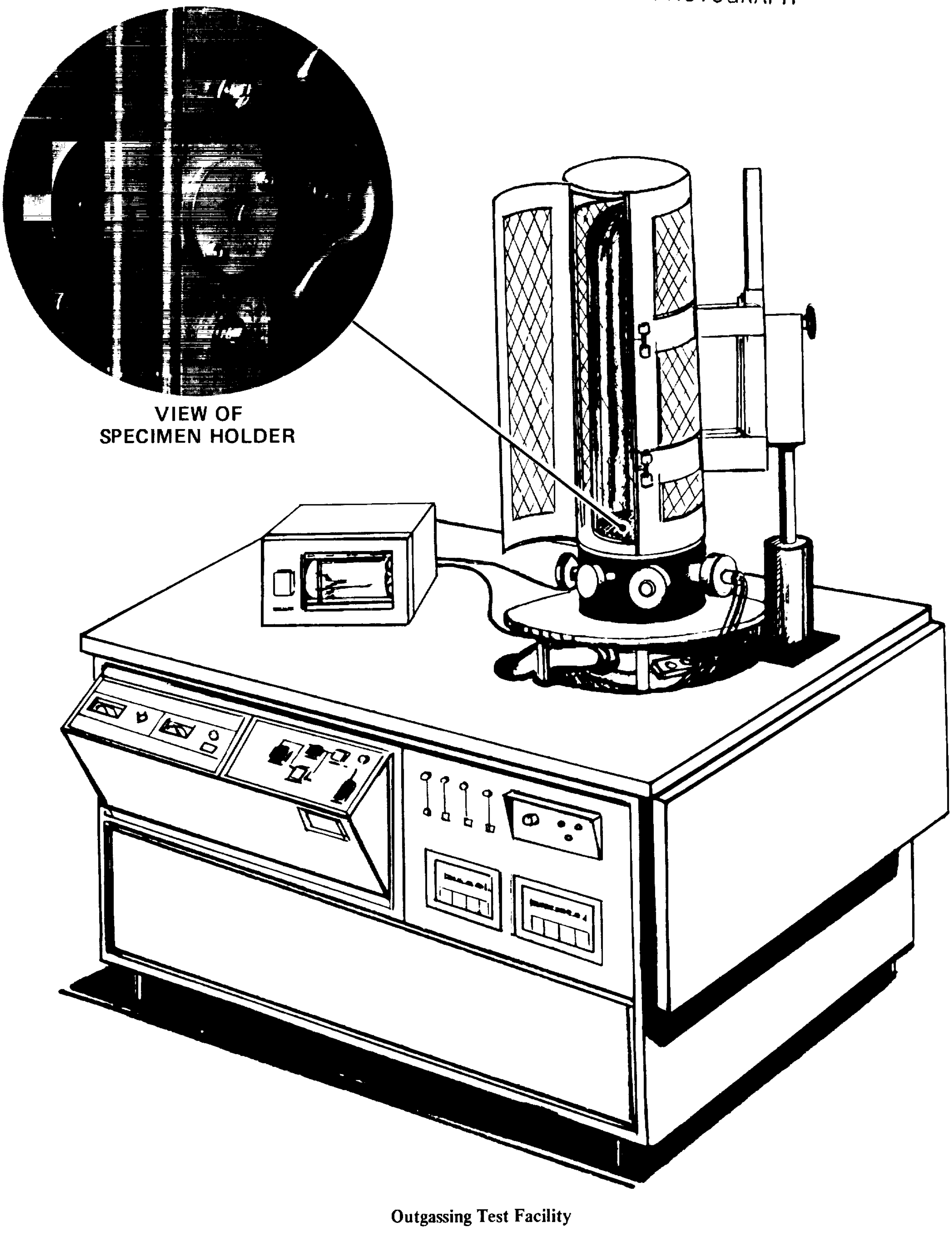


Outgassing Test Facility

FATIGUE, FRACTURE MECHANICS & MECHANICAL TESTING LABORATORY

DESCRIPTION

The Fatigue, Fracture Mechanics and Mechanical Testing Laboratory performs:

- tensile and bending fatigue testing of sheet, plate and bar metallic materials,
- fracture mechanics testing, including flaw growth and fracture toughness testing of metals and ceramics,
- mechanical testing, including tensile and compression testing of metallic and nonmetallic materials, and
- static and dynamic fatigue testing of glass and ceramic materials.

MODE OF OPERATION

Equipment is set up and controlled manually. Display formats on charts or XY plots are utilized with some automatic processing of data. Results are analyzed and reported.

DATA ACQUISITION CAPABILITIES

High strain rate testing on the Servo-Hydraulic Fatigue Machine and Tension Compression Tester uses a TEKTRONIX 390 AD programmable waveform digitizer and CRT display.

An INSTRON Microcon II microprocessor automatically processes data produced on the Tension Compression Tester. The Static Fatigue Tester uses an ACTION INSTRUMENTS X200 computer to record sample break times.

INTEGRAL INSTRUMENTATION

Servohydraulic Fatigue Machine .... digital readout of load, stroke or strain

Tension Compression Tester .... strip chart output of sample load and strain

Static Fatigue Tester ...... break times recorded by a computer

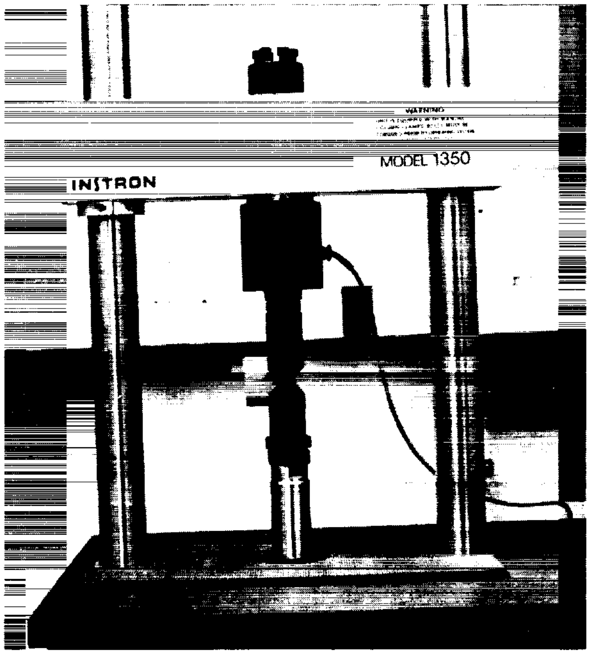
Plate Fatigue Machine .... break times noted manually

PARAMETERS

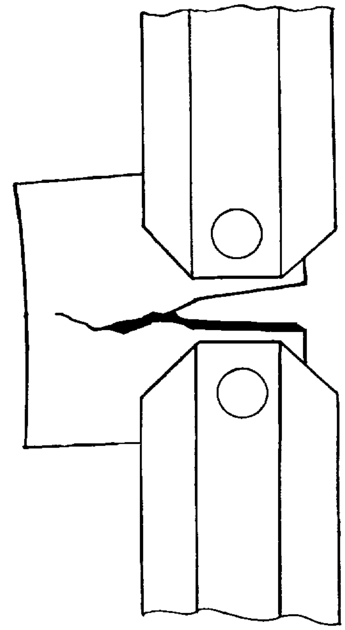
	Servo-Hydraulic Fatigue Machine	Tension-Compression Tester	Plate Fatigue Machine	Static Fatigue Tester
Maximum load range, lb	±20,000	±20,000	±150	±10
Minimum load range, lb	±100	±5	±15	±1
Maximum cycling frequency, Hz	5	1	30	N/A
Crosshead travel or stroke range, in	4	42	2	N/A
Crosshead or stroke speed range, in/min	0–180	0.005 to 20	3600	Static
Sample Size (see notes)	1, 2	3	5	4

Notes:
1. 0.50" or 1.0" thick compact tension specimens, per ASTM E-399.
2. axial fatigue specimens, per ASTM E-466, dia = 0.25".
3. 0.5" wide flat specimens, per ASTM E-8.
4. ceramic or glass specimens 0.05" thick x 0.38" W x 2.5" L.
5. TATNALL-KRAUSE tapered plate specimen.

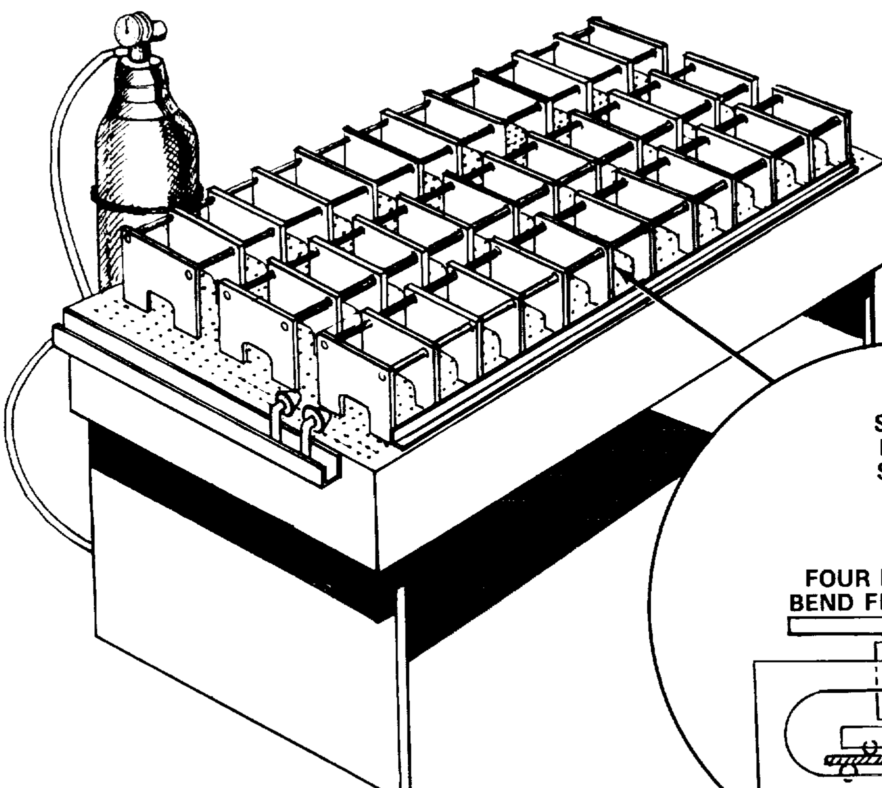
CONTACT – Michael Barthelmy, Code 313 (Materials Branch), NASA Goddard Space Flight Center, Greenbelt, MD 20771, 301-286-8472.



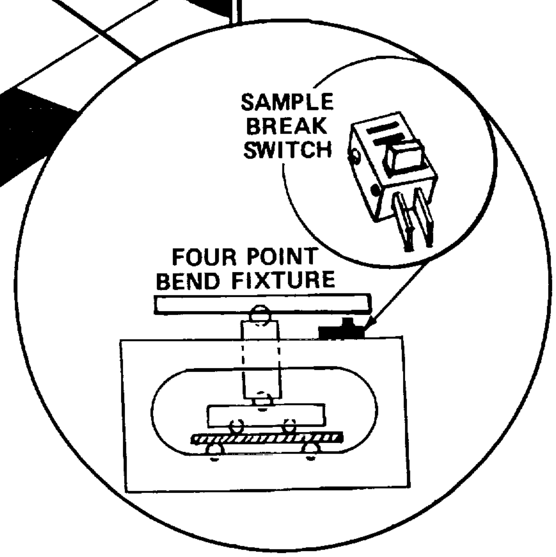
Servo-Hydraulic Fatigue Machine



Fracture Toughness Test



Static Fatigue Test Station



Typical Test Specimen